DELIVERING SUSTAINABLE TRANSPORTATION INFRASTRUCTURE: CRITICAL ROLE OF A COMPREHENSIVE FEASIBILITY STUDY

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DELIVERING SUSTAINABLE TRANSPORTATION INFRASTRUCTURE: CRITICAL ROLE OF A COMPREHENSIVE FEASIBILITY STUDY

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PROMOTER: PROF INNOCENT MUSONDA
CO-PROMOTER: DR JUSTUS AGUMBA

DEDICATION

This work is dedicated to my family: my husband, Lawrence, and children, Victoria Ogechimere and twins, Alexandra Somkene and Alexander Gozie.

DECLARATION

I declare that this is my original work and that I am the author, except for material that is clearly identified and is acknowledged to its original source. All the reviewed sources have been referenced accordingly. This thesis is submitted to the University of Johannesburg in fulfilment of the requirements for the degree of Doctor of Philosophy in Engineering Management. It has not been presented for the same purpose and/or in the same form elsewhere.

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EXECUTIVE SUMMARY

Infrastructure project owners, decision makers, planners and investors decide to proceed with a given project based on the results of feasibility studies carried out at the planning stage. The feasibility studies identify different aspects of the project that pose risks to the sustainability and performance of the projects concerned. Therefore, a feasibility study that addresses all factors related to a project and done correctly, is critical to the decision makers.

Feasibility studies for transportation infrastructure is even more critical in view of the many factors that should be considered and the capital required to develop infrastructure. Sustainability in terms of financial, physical infrastructure, service quality, as well as strategic and institutional support will not be achieved if a comprehensive feasibility study is not conducted at the concept stage of the transportation infrastructure project. A poorly defined project at the feasibility stage does not deliver the same outcome as a well-defined project, irrespective of how well it was executed and operated.

The current study therefore argued that some of the problems and challenges encountered in the operational stage of transport infrastructure projects can be mitigated by according considerable attention to how feasibility studies are conducted and the factors that may contribute to undesirable outcomes at the operational stage of transportation infrastructure projects. The study posited that the performance of transportation infrastructure projects can be sustained if attention is given to conducting and delivering comprehensive feasibility studies. Comprehensive feasibility studies provide relevant and sufficient information with regard to identified risks and uncertainties, which may affect the project. In addition, measures necessary to mitigate the occurrence of such risks must be identified. Moreover, alternative solutions should be assessed in a comprehensive feasibility study. Poor quality of feasibility studies entails that risks, benefits as well as impacts of the proposed project are not well accounted for; thus, leading to disastrous consequences during the project's operational stage.

Evidence from preliminary literature review and global events suggested that poor quality of feasibility studies contributed to failures of panoply of transportation infrastructure projects. However, there was no consensus among extant studies on the factors that should be considered in a comprehensive feasibility study in order to ensure sustainable performance of transportation infrastructure projects. In addition, the impact significance of transportation infrastructure feasibility studies, and more importantly, the mediating roles of people and procedures in producing good quality feasibility studies, and in turn sustainable performance, had not been evaluated. Consequently, this study pursued an investigation into establishing significant feasibility study factors, which should be incorporated in a comprehensive feasibility study, and the extent to which feasibility studies, mediated by the people and procedures impact on infrastructure project sustainability.

Therefore, an investigation on how feasibility studies were conducted on identified projects, establishing specifically, which elements were critical to feasibility studies, the quality of feasibility studies and the sustainability of the projects was done. A conceptualised Transportation Infrastructure Feasibility Study (TIFS) model to ensure infrastructure sustainability was tested and validated. The postulated TIFS model was that an evaluation of investment appraisal method, finance availability and source, user needs, local environment, available data and strategic support for the project should be done. Coupled with the quality of the feasibility study defined by the people and processes involved in conducting the TIFS, the author argued that project sustainability was assured and would give confidence to decision makers to endorse a project.

Literature was reviewed on transportation infrastructure feasibility studies and project sustainability. Mixed methods (sequential exploratory) approach was adopted in the study. Multi-case studies using document analysis and interviews among feasibility study consultants and project managers in Johannesburg, South Africa, were undertaken as part of data collection. Findings from the literature and cases studies were used to develop a transportation infrastructure feasibility study (TIFS) model. A pilot-tested questionnaire survey was subsequently undertaken in the nine provinces of South Africa for the purpose of validating the conceptual model. The results of the pilot test are not presented in the current thesis as it served to simplify and clarify some of the questions and to reduce the length of the questionnaire. Therefore, a number of questions were deleted and others rephrased considerably. The pilot-testing also served to identify essential research approval processes in the government entities sampled, which were observed to differ from one to another. The questionnaire was further reviewed and refined by experts and consultant statistician before approval by the University's Ethics Committee and final dissemination.

The final questionnaire, with 5-point Likert scale items on feasibility studies and project performance, was distributed by hand, as well as online using email and google forms. Respondents comprised built environment professionals who had worked on transportation infrastructure projects, selected through purposive and snowball sampling methods. Participants were contacted telephonically and through emails and requested to participate. Participants were also identified through contacts made during the pilot and qualitative phase of the study, who made further referrals. A total of 132 questionnaires were returned and used for quantitative analysis.

The outputs from the qualitative data analysis, with the aid of ATLAS-ti software version 7 were themes on how feasibility studies were conducted and which factors were incorporated in the feasibility studies. Quantitative analysis of data from the questionnaire survey was undertaken using the Statistical Package for the Social Sciences (SPSS) version 25 and the model validation was done with Analysis of Moment Structures (AMOS) version 25. Outputs from the SPSS were descriptive statistics (mean, standard deviation, median and interquartile range scores) and inferential statistics (exploratory factor analysis - EFA). The emerging structures from the EFA were thereafter run through structural equation modelling (SEM) to validate and test the postulated TIFS model.

Findings from the investigation was that the quality of feasibility studies was influenced by the TIFS factors including methods used in appraisal, finance and data available as well as consideration of user needs, strategic support and local environment and conditions. The results indicated that the people and processes depended on the degree to which the TIFS factors were incorporated in the feasibility studies. Additionally, the quality of feasibility studies was found to be predictive of project sustainability. This suggested that the higher the involvement of the right people and time taken to traverse through the feasibility study phase of identifying and evaluating alternatives, developing appropriate strategies, and making reliable decisions, the better the project performance at the operational stage.

Further findings yielded support for the theorised hypothesis between the TIFS model and project sustainability. The indirect effect of the TIFS factors on project sustainability was also statistically significant. The relationship was direct, as well and indicative of the fact that without adequate attention to the identified TIFS factors during the critical stage of feasibility studies, the chances of delivering sustainable transportation projects able to fulfil the intended objectives over their life cycle, are slim.

The limitations of the study warrant mention. Environmental sustainability in terms of greening was not incorporated in the study. The influence of project characteristics on the quality of feasibility studies was not evaluated further in the quantitative phase. Further studies are recommended to statistically establish the relations between project characteristics and the quality of feasibility studies. The findings of the study may be generalisable to other parts of South Africa that were not reached during the quantitative phase of the study.

The current study provided invaluable evidence on the critical factors that should be considered in comprehensive feasibility studies, on which transportation infrastructure stakeholders can make reliable decisions about the potential worthiness and sustainability of intended projects. Transportation infrastructure planners and investors in infrastructure can devise strategies to produce comprehensive feasibility studies. Adequate attention to the TIFS factors during feasibility studies would ultimately result in a comprehensive feasibility study. With the holistic consideration of the TIFS factors in identifying potential risks, impacts and involvement of the right people in the decision-making process, appropriate selection of projects that are likely to be sustainable, would result.

Keywords: feasibility studies, infrastructure, project performance, South Africa, sustainability, transportation.

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LIST OF ABBREVIATIONS

AMOS	Analysis of Moment Structures
APA	American Planning Association
ASCE	American Society of Civil Engineers
ADB	Asian Development Bank
BOOT	Build-own-operate-transfer
BRT	Bus rapid transit
CARINBE	Centre for Applied Research and Innovation in the Built Environment
CBA	Cost-benefit analysis
CBS	Columbia Broadcasting System
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CoJ	City of Johannesburg
DBSA	Development Bank of Southern Africa
DBO	Design-build-operate
DTUK	Department for Transport in the United Kingdom
DoT	Department of Transport, South Africa
EC	European Commission
EFA	Exploratory factor analysis
EIA	Environmental Impact Assessment
EIEB	Environmental Impact Evaluation Bureau
ETSC	European Transport Safety Council
EU	European Union
FHWA	Federal Highway Administration
FQ	Feasibility study quality
GCR	Global Construction Review
GDP	Gross Domestic Product
GES	Global Excellence and Stature Scholarship
GMA	Gautrain Management Agency
GO	General objectives

GPDRT	Gauteng Province Department of Roads and Transport
ICA	Infrastructure Consortium for Africa
ICT	Information and communication technology
IDB	Inter-American Development Bank
IRPTN	Integrated rapid public transport networks
ITMP	Integrated Transport Master Plan
IQR	Interquartile range
JDA	Johannesburg Development Agency
JRA	Johannesburg Roads Agency
KMO	Kaiser-Meyer Olkin
LCA	Life cycle assessment
MAR	Missing at random
MCAR	Missing completely at random
ML	Maximum likelihood
MTEF	Medium Term Expenditure Framework
NRC	National Research Council
OECD	Organisation for Economic Cooperation and Development
PAF	Principal axis factoring
PCA	Principal components analysis
PLS	Partial least squares
PPP	Public-private partnership
PPPIRC	Public-private partnerships in infrastructure resource centre
PWC	Price Waterhouse Cooper
PS	Project sustainability
QOL	Quality of life
RCF	Reference class forecasting
RMSEA	Root mean square error of approximation
RSA	Republic of South Africa
SA	South Africa
SANRAL	South Africa National Roads Agency Ltd.
SEM	Structural equation modeling

SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
SRMR	Standardised root mean square residual
SWOT	Strengths, weaknesses, opportunities and threats
TIFS	Transportation infrastructure feasibility study
UK	United Kingdom
UNECA	United Nations Economic Commission for Africa
US	United States
USC	University of Southern California
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VTPI	Victoria Transport Policy Institute
WCED	World Commission on Environment and Development

LIST OF APPENDICES

LIST OF PUBLICATIONS FROM THE STUDY

Book Chapter

Musonda, I., Gumbo, T., Bwanyire, B., Musakwa, W., Okoro, C. and Gil, N. (2019). No One-Size-Fits-All Organizational Solution: Learning from Rapid Rail Developments in Ethiopia and South Africa. In Dualities by Design: A Global Race to Build Africa's Infrastructure. Eds: N. Gil, A. Stafford, I. Musonda. ***In print.*** https://www.cambridge.org/gb/academic/subjects/management/organisation-studies/duality-design-global-race-build-africas-infrastructure?format=HB

Journal

Okoro, CS., Musonda, I. and Agumba, J. (2019). Validity and reliability of a transportation infrastructure sustainable performance framework: A study of transport projects in South Africa. *Construction Economics and Building*, 19(2): 126-143.

Conference Papers

1. Okoro, C. S., Musonda, I. and Agumba, J. N. (2019). An exploratory factor analysis of transportation project sustainability indicators: A case of projects in South Africa. The CIB World Building Congress 2019. 17-21 June 2019. Hong Kong, China
2. Okoro, C. S., Musonda, I. and Agumba, J. N. (2019). Planning considerations for smart and sustainable transportation infrastructure: Case study of non-motorised transport facilities in Johannesburg, South Africa. The CIB World Building Congress 2019. 17-21 June 2019. Hong Kong, China.
3. Okoro, C. S., Musonda, I. and Agumba, J. N. (2019). Validating a framework of transportation infrastructure project sustainability measures. Associated Schools of Construction of Southern Africa (ASOCSA) Conference 2019, 2–3 September, 2019. Durban, South Africa.
4. Okoro, C. S., Musonda, I. and Agumba, J. N. (2019). A factor analysis of transportation infrastructure feasibility study factors: A study among built environment professionals in South Africa. The Eleventh International Conference on Construction in the 21st Century (CITC-11) 9–11 September, 2019, Westminster, London, United Kingdom.

5. Okoro, CS., Musonda, I. and Agumba, J. (2018). Sustainability indicators for a transportation infrastructure investor. The Tenth International Conference on Construction in the 21st Century (CITC-10). July 2-4, 2018, Colombo, Sri Lanka.
6. Okoro, CS., Musonda, I. and Agumba, J. (2018). Value-in-use sustainability factor as a driver for asset management of road transport infrastructure. 10th CIDB Postgraduate Conference. March 2018. Cape Town, South Africa.
7. Okoro C. S., Musonda I., and Agumba, J. N. (2018). Critical planning considerations for ppp road project sustainability: A case study approach. International conference on infrastructure development and investment strategies in Africa. 11–13 July, 2018. Livingstone, Zambia.
8. Okoro C. S., Musonda I., and Agumba, J. N. (2018). Social sustainability of road transportation infrastructure: An integrative review of managerial plans and planning considerations for safety assurance. Proceedings of the Joint CIB W099 and TG59 Conference, Salvador, Brazil, 1-3 August 2018.
9. Okoro, CS., Musonda, I. and Agumba, J. (2017). Feasibility study considerations for transport infrastructure performance: A desk study. The Ninth International Conference on Construction in the 21st Century (CITC-9). March 5-7, 2017, Dubai, United Arab Emirates.
10. Okoro, CS., Musonda, I. and Agumba, J. (2017). An integrative literature review of critical liveability indicators in urban transport infrastructure planning. TG59 and CIB W099 Conference, Cape Town, South Africa June, 2017.
11. Okoro, CS., Musonda, I. and Agumba, J. (2017). A desk study of road infrastructure performance measurement criteria. International Conference on Infrastructure Development and Investment Strategies in Africa. Livingstone, Zambia. 30 August – 1 September, 2017. Livingstone.
12. Okoro, CS., Musonda, I. and Agumba, J. (2016). Critical considerations in transport service demand forecasting: A literature review. International Conference on Infrastructure Development and Investment Strategies in Africa. Livingstone, Zambia. August 2016.
13. Okoro, CS., Musonda, I. and Agumba, J. (2016). Traffic demand determinants: A review of long-term scenario effects. 5th Construction Management Conference, Port Elizabeth, South Africa, November, 2016.

DEFINITION OF KEY TERMS

Comprehensive

The term “comprehensive” concerns ‘a range of factors about the way things ought to be, and which form a conception of the good and inform judgements’ (Voice, 2014). The Oxford Dictionary (online) defines the term ‘comprehensive’ as “including all, or almost all, the items, details, facts, information, etc., that may be concerned” (Oxford Learner’s Dictionary, online). The term “comprehensive” refers to ‘the need for a single tool to perform all required actions, at all stages, covering all disciplines’ (Johnson, 2013). In the current study, the term “comprehensive” means the inclusion of all relevant feasibility study factors which potentially influence the operation of transportation projects.

Feasibility study

A feasibility study is the analysis and evaluation of future investment objective and potential, costs and benefits, in a given time span, while taking into account uncertainty and risk factors. The purpose of feasibility studies results from its comprehensiveness and quality as a technical-economic instrument, on the basis of which the viability of the project is attested (Viorica, 2010:127; Abou-Zeid, 2007:19). The current study focuses on processes, structures, data, appraisal methods, and criteria factors considered and incorporated into feasibility studies, which pose risks to the sustainability of proposed projects in terms of financial, economic, and social benefits accruable from transport investments during operations (Mišić and Radujković, 2015; Bracarense *et al.*, 2016).

Comprehensive feasibility study

A comprehensive feasibility study is a detailed plan and prediction of outcomes of a project, undertaken through process stages, based on an array of related or unrelated parameters, all of which are subject to change to an extent of uncertainty resulting in a wide discrepancy between predicted and actual outcomes (Macdonald, 2007). A comprehensive feasibility study is a structured way of assessing the technical, financial, social, and environmental viability or practicality of a project, which is used to make decisions about whether a project should be implemented (Jayasinghe and Baillie, 2017). A comprehensive feasibility study, in the current study, purports inclusion of all possible factors in the evaluation of the potential performance of transportation infrastructure projects.

Performance measurement

This is the analysis of how well policies, programs and projects perform with regard to their intended goals (Dhingra, 2011:2). Performance measurement entails monitoring and evaluation of different aspects that commonly affect operating conditions such as traffic flow, safety, road maintenance conditions, accessibility and environmental impact (Fancello *et al.*, 2014:559). The latter definition was adopted in this study as it relates closely to transport infrastructure. Performance measures are alternatively named performance indicators, transportation statistics, sustainable transport indicators (Dhingra, 2011:2).

Sustainability

The World Commission on Environment and Development (WCED) opined that transport infrastructure development is deemed sustainable when the needs of the present are met without compromising the ability of future generations to meet their own needs (WCED, 1987:16). In the opinion of the Asian Development Bank (ADB), 2013), sustainability of transportation infrastructure projects refers to the continuation of transport services, and corresponding benefits, from the facilities. Incorporating these definitions, the current study defines sustainability of transport infrastructure as “long-lasting potential or a state in which projects continue to fulfil the objectives for which they were implemented”, and incorporates benefits accruable to an investor as well as the users.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The transport sector and the mobility it confers impacts directly on the development and welfare of the population. This is achieved through employment creation and therefore enhances economic development and provision of social services (Chen and Cruz, 2012:136; Vilana, 2014:6; Development Bank of Southern Africa (DBSA), 2012:133). Hence, the sustainability of transport infrastructure projects in terms of leveraging maximum possible returns on investment while still preserving and maintaining the assets in such a condition as to continue fulfilling intended objectives over generations of users, has been the focus of attention for decades (Ramani *et al.*, 2009; DBSA, 2012:6).

The concept of sustainability in transport infrastructure development is defined by the American Society of Civil Engineers (ASCE) as a set of environmental, economic, and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life (QOL) indefinitely without degrading the quantity, quality or availability of natural, economic and social resources (Surbeck and Hilger, 2014:2080). According to the World Commission on Environment and Development (WCED), transport infrastructure development is deemed to be sustainable when the needs of the present are met without compromising the ability of future generations to meet their own needs (Bryce, 2008; Bongardt *et al.*, 2011). Therefore, sustainability includes all aspects that would enable an infrastructure project to continually function and serve as expected or planned over generations of users. Sustainability should not be a fixed state of harmony, but rather a process of change in which the direction of investments, exploitation of resources and expectations of revenue and benefits are made consistent with future as well as present needs. Achieving successful and sustainable operations throughout the life span of transport infrastructure should be the focus in transport project planning and development (Glaister *et al.*, 2010:3). Hence, sustainability is posited in the current study as the "long-lasting potential or a state in which transport infrastructure projects continue to fulfil the objectives for which they were implemented".

However, sustainable transport infrastructure development is being blighted by cost overruns, stakeholder opposition, contractual disputes, inadequacy of public funding and unavailability of continued financing for maintenance and operations (Ramani *et al.*, 2009:30; Beckers and Stegemann, 2013:1). According to Merrow (2011) and Mišic and Radujković (2015:73), the proportion of mega infrastructure project failure, globally, is as high as 66%, with cost overruns of over 50%, and a significant proportion of these projects fail to meet the objectives for which they were constructed. Transport infrastructure should therefore be sustainable where various features including accessibility, mobility, reliability, efficiency, safety and security, social equity, people and environmental friendliness, convenience and comfort are ensured for generations of users (Yatskiv and Budilovich, 2017:480).

Transportation infrastructure developments should consider sustainability elements beyond the three-dimensional economic, social and environmental (legislative requirements) aspects (Jeon *et al.*, 2010; Stapledon, 2012). This is because such projects have unique characteristics with regard to location and system management and therefore should include factors relative to its performance in the long run. These would include system effectiveness (which captures the concept of mobility/fluidity of movement), technical or structural quality of roads, environmental sustainability (preservation of green spaces) as well as impacts on the social quality of life and economy as a whole (Haas *et al.*, 2009; Ramani *et al.*, 2009; Jeon *et al.*, 2010; Kaare and Koppel, 2012; Montgomery *et al.*, 2015). Attention ought to be given to the physical sustainability of projects as well as impact on people (both present and future) for which the infrastructure is planned because externalities are engendered by the users themselves (intra-sectoral externalities, such as congestion) the environment, and shifted or imposed on the society at large (pollution and accidents, for instance) (World Bank, 2013).

In addition, the long-lasting potential of the projects to deliver expected financial returns is important. The financial performance of transport projects is important to investors or sponsors because revenue which mainly accrues from the sale and use of goods and services is provided by the system. The revenue that accrues from a given investment and the factors that affect it need to be assessed at the planning stage. Such factors include future demand, expected benefits and costs. The ultimate success or failure of a given project and the entities intending to invest depends on the outcome of feasibility studies that reveal expected (future) performance of the projects (Alasad *et al.*, 2012:328; Mišic and Radujković, 2015:72). Therefore, development and investment in transport infrastructure needs to be done in such a way that income-producing opportunities are not pursued in ways that would limit or close off opportunities for future generations (Montgomery *et al.*, 2015:3).

Sustainability of transportation infrastructure may be ensured through good feasibility studies that are comprehensive. A comprehensive feasibility study is a detailed plan and prediction of outcomes of a project, undertaken through process stages, based on an array of related or unrelated parameters, all of which are subject to change to an extent of uncertainty resulting in a wide discrepancy between predicted and actual outcomes (Macdonald, 2007). A comprehensive feasibility study is a structured way of assessing the technical, financial, social, and environmental viability or practicality of a project, which is used to make decisions about whether a project should be implemented (Jayasinghe and Baillie, 2017). Such parameters include environmental, technical, project financial (including costs and revenues), physical plans and details for a project, which can be modified, replaced or discarded until the most satisfactory combination of options is selected (Macdonald, 2007). Therefore, there is little chance that future generations would benefit from transport infrastructure developments whose foreseeable complexities and uncertainties with regard to costs, demand and benefits (financial and/or economic and social), are not adequately, accurately and explicitly assessed and addressed at the planning stage of the projects (Flyvberg *et al.*, 2014; Montgomery *et al.*, 2015:v).

According to Nicolaisen and Driscoll (2014), poor performance of transport projects is partly attributed to the poor quality of feasibility studies where wrong and misleading predictions are put forward to support viability of proposed projects. For instance, Bangkok's US$2 billion Skytrain, which was overestimated by a huge margin (with passenger forecast 2.5 times higher than the actual traffic), resulted in the construction of needlessly long station platforms, large terminals, and acquisition of a large number of trains, leading to the project company landing in financial trouble (Flyvbjerg, 2005b). In this Bangkok's skytrain example, the forecasts turned out to be incorrect. It appeared that over-investing in idle capacity in a developing nation where capital for investment is scarce was not a good initiative after all, even though it seemed so in a congested and air-polluted city, Bangkok. In another case, the Channel tunnel's Eurostar train project demand forecast was overestimated, with the passengers numbering only 45% of the estimate for the opening year, resulting in several near bankruptcies (Flyvbjerg *et al.*, 2005). Similarly, the first toll motorway in Hungary (M1/M15) experienced 40% lower traffic than was expected albeit the forecasts were prepared by independent experts (Cuttaree *et al.*, 2009). Consequently, the concessionaire was unable to service its debt and the government had to take over the concession at a high cost. Lower than predicted revenues, from less than expected passenger traffic, place project viability at risk and redefine projects that were initially promoted as effective vehicles to economic growth as possible obstacles to such growth (Parthasarathi and Levinson, 2010; Liyanage and Villalba-Romero, 2015).

On the other spectrum, with regard to underestimation of traffic demand, South Africa's first high-speed metropolitan transport network, Gautrain, which was developed at a cost of nearly R25 billion, has reportedly reached its predicted number of users four years earlier than anticipated as it is currently commuting the number of passengers it had planned to achieve in 2020, which is about 60,000 passengers per day (Nicolaides, 2016). In addition to the apparent congestion at the stations resulting from this, the unexpected high numbers have meant that there will be more expenses which will be incurred in order to provide forty-eight additional carriages to cater for the current number of people using the trains daily. This plan would undoubtedly require a tendering process, obtaining permissions, and construction activities which have negative impacts on nearby populace during development as well as extra costs which could have been channeled into other development plans. In another example, the e-tolls project in the Gauteng Province of South Africa did not include the community as the stakeholders in the decision-making process. As a result, there has been public opposition and the government is currently losing financially.

In a similar case, forecasts of traffic patterns on the Kazungula bridge, crossing the Zambezi River, between Zambia and Namibia, were predicted to grow between 1.75 times (in the case of low growth rate scenario) and 2.56 times (for high growth rate scenario) by 2015 (Infrastructure Consortium for Africa (ICA), 2007). However, the actual traffic had exceeded the original estimation and thus warranting expansion of the bridge project to handle road and rail traffic into Zambia. Therefore, it appears that poor performance of transport projects is partly attributable to inaccurate predictions put forward in feasibility studies to support the decision to invest and build.

Inaccurate feasibility studies can lead to inadequate assessment and management of risks inherent in projects. Consequently, the costs incurred to remedy the consequences of inaccurate estimates are immense and reduce the social benefits. On the part of a financier, it is a business opportunity lost since the payback period expires sooner than expected. Poor feasibility studies distort performance outcomes quite drastically which in turn can lead to a different prioritisation of investments than if the correct information had been available to investors prior to investments (Nicolaisen *et al.*, 2012:6). On the other hand, finding alternative ways to mitigate the consequential problem of congestion (in underestimated projects) may be expensive and impose economic burdens on the community. Furthermore, capacity relief on congested links could turn out to be lower than planned and this could result in a significant distortion of the social viability of projects and implementation of non-viable projects.

Therefore, if huge discrepancies between expected and actual outcomes occur, the magnitude of inherent risks and uncertainties which materialise at the operational stage is unplanned for, and the result can be a project failure (Nicolaisen and Driscoll, 2014). Non-comprehensive feasibility studies of transportation infrastructure may lead to financial, economic and social risks, which threaten the sustainability of the project in the long run (Bryce, 2008; Haas *et al.*, 2009; Kaare and Koppel, 2012; Liepziger and Lefevre, 2015; Liu *et al.*, 2015; Liyanage and Villalba-Romero, 2015; Mišic and Radujković; 2015; Rudžianskaitė-Kvaraciejienė *et al.*, 2015; Yatskiv and Budilovich, 2017). Therefore, the quality of feasibility studies appears to be a critical factor to the sustainability of transportation infrastructure projects.

Previous studies conducted on the impact of feasibility studies reveal that a number of factors affect the quality of feasibility studies. For instance, the methods used in the appraisal of the investment, could result in different margins of error (Flyberg *et al.*, 2006; Al-Masaeid and Al-Omoush; 2014; Jeerangsuwan *et al.*, 2014). Some methods used singly, for instance, environmental impact assessment, could result in inadequate consideration of the interactions between various complex systems and influencers which could affect the project during the operational stage (Etemadnia and Abdelghany, 2011; Gajendran *et al.*, 2015). Other studies suggested that the nature and availability of data used could influence the quality of feasibility studies (Kim, 2007; Etemadnia and Abdelghany, 2011; Hassan *et al.*, 2013). High dependency on historical information such as traffic data, could be misleading in a highly dynamic and congested area (Etemadnia and Abdelghany, 2011). Considerable attention should be given to factors that influence feasibility studies in order to develop appropriate strategies to ensure sustainability (Chen and Cruz, 2012; Mišic and Radujković; 2015; Rudžianskaitė-Kvaraciejienė *et al.*, 2015). These views suggest that feasibility studies incorporate elements that may impact on a project's performance. These may include finance availability and procurement strategies (Glaister *et al.*, 2010), local environment (Rudžianskaitė-Kvaraciejienė *et al.*, 2015), institutional support (Quium, 2014), and users' needs (Alasad *et al.*, 2012; 2013; Valentin *et al.*, 2012; Erlich, 2015; Kraul, 2015; Mišic and Radujković, 2015).

In addition, the people involved may affect feasibility studies and the procedures followed during the feasibility studies. Nicolaisen *et al.* (2012) and Flyvberg *et al.* (2014) indicated that inadequate or incorrect feasibility assessments are the result of delusions (psychological biases) or honest mistakes and deceptions or strategic manipulations of information by the people involved. On their part, Hyari and Kandil (2009) contend that a lack of understanding of the basic underlying processes involved in feasibility studies results in unreliable outcomes. The procedures followed, which require designating time and effort into conducting feasibility studies, are important because errors could be introduced and some critical aspects may be omitted (Rosenthal *et al.*, 2015). Therefore, good quality feasibility studies are also reliant on or mediated by the people and processes involved.

However, although studies had been conducted on feasibility studies and transportation project sustainability, no study had evaluated the impact of a comprehensive feasibility study on project sustainability or the mediating role of the quality of feasibility studies, measured by the people and processes involved, in ensuring sustainability. Consequently, this study pursued an investigation into establishing significant feasibility study factors and the extent to which feasibility studies, mediated by the people and procedures impact on infrastructure project sustainability. The findings of this study therefore provide the minimum factors that should be critically considered in feasibility studies, on which transportation infrastructure stakeholders can make reliable decisions about the potential worthiness and sustainability of intended projects. In this way, limited resources can be allocated among alternative infrastructure needs as efficiently as possible.

1.2 PROBLEM STATEMENT

Inadequate feasibility studies result in transportation infrastructure project failure. Poor project performance is partly attributed to non-comprehensive and poor quality of feasibility studies which result in shortfalls in benefits, cost overruns, stakeholder dissatisfaction, low demand, and unfavourable institutional environment, as was the case on the Bangkok's US$2 billion Skytrain (Flyvbjerg, 2007b; 2009), and more recently, the bus rapid transit (BRT) and e-toll projects in South Africa (Wray and Gotz, 2014; Stefánsdóttir, 2015; Monama, 2017). Consequently, projects with an inadequate front-end feasibility phase that considers all uncertainties may not perform well (Mišić and Radujković, 2015).

Previous studies on the role of feasibility studies in ensuring improved performance and sustainability of transportation infrastructure projects did not investigate the extent of the relationship between feasibility study factors and the mediating roles of people involved and procedures on project performance. Therefore, this study argues that if comprehensive feasibility studies are not undertaken, the project's future performance is compromised and the chances that projects will deliver intended objectives in the expected life cycle are slim.

1.3 GAPS IDENTIFIED

Although studies had been conducted on the factors which impact on the quality of feasibility studies (Hyari and Kandil, 2009; Nicolaisen *et al.*, 2012; Flyvberg *et al.*, 2014) and sustainability of projects (Glaister *et al.*, 2010; Rudžianskaitė-Kvaraciejienė *et al.*, 2015), the extent to which the various factors affect the sustainability of transportation infrastructure projects is neither clear nor agreed on. Understanding the significant factors will assist in developing a comprehensive feasibility study. Absence of a comprehensive feasibility study framework demanded that an investigation on the most critical factors of transportation projects be undertaken.

In addition, the relationship between feasibility studies and project sustainability had not been evaluated. Kaare and Koppel (2012) compared performance management approaches used in feasibility studies for projects in extant literature with practices in Estonia and acknowledged a relationship between feasibility study methods used and performance outcomes only, but did not reveal these relationships statistically. In similar studies, Parthasarathi and Levinson (2010) and

Liyanage and Villalba-Romero (2015) revealed that traffic demand factors omitted in forecasts could result in underestimated costs and overestimated benefits which in turn are detrimental to transport projects while in operation. However, these relationships were not statistically evaluated. Further, the influence of stakeholders' opinion on project costs and acceptability were investigated in Canterelli *et al.* (2010) and Valentin *et al.* (2012), respectively. However, these studies were too narrow, excluding other important aspects of feasibility studies and project sustainability and so may not be comprehensive.

Therefore, in the absence of consensus on the components of a comprehensive feasibility study, and a study, which evaluated the impact significance of transportation infrastructure feasibility studies on project sustainability, the current study investigated that relationship, and more importantly, the mediating roles of people and procedures in producing good quality feasibility studies required an inquiry. In this regard, the study provides theoretical, conceptual, empirical or methodological contribution to the body of knowledge and practice.

On the above backdrop, the questions that arose for investigation were: what factors are incorporated in transportation infrastructure feasibility studies; how do the factors influence the quality of feasibility studies, and in turn, performance of projects? The general hypothesis postulated was therefore that the factors considered in feasibility studies impact directly and indirectly (mediated by the quality, measured by the people and processes involved) on the performance of projects during the operational stage. This was the premise of the current study.

1.4 THE STUDY

1.4.1 Aim

The study aims to provide useful information to identify core factors that should be considered in a feasibility study, which would invariably contribute to the sustainability of transportation infrastructure projects. The evidence is envisaged to be useful to transportation infrastructure investors, policy makers and stakeholders in identifying and deciding on the potential and worthwhile transportation infrastructure projects to invest in, based on evidence from comprehensive feasibility studies, with the assurance of future desirable performance and sustainability of the subject projects.

1.4.2 Objectives

The general objectives (GO) of the study were to:

GO1. Determine how feasibility studies are conducted and thus critical factors in transportation infrastructure feasibility studies.

GO2. Establish the role and impact of feasibility studies on transportation infrastructure sustainability.

GO3. Develop a transportation infrastructure feasibility study model for sustainability of transportation infrastructure.

GO4. Validate the conceptualised model for transportation infrastructure sustainability by comparing the outcomes from the literature review, qualitative and quantitative phases.

Objective GO1 was achieved through a literature review and qualitative enquiry. These provided a theoretical background and framework on the critical factors considered in feasibility studies for transportation infrastructure projects. The objectives GO2 to GO4 were achieved through the quantitative study, which enabled testing of the theorised model using structural equation modelling (SEM).

1.4.3 Research questions

The specific research questions for the qualitative phase were:

1. How were the feasibility studies of the transportation infrastructure projects conducted?
2. What factors were integrated during the feasibility studies for the projects?
3. How are the projects performing during the operational stage?

The specific research questions for the quantitative phase were:

1. What factors are critical in transportation infrastructure feasibility studies (TIFS)?
2. What is the impact significance of the TIFS factors on the quality of feasibility studies?
3. What is the impact significance of the quality of feasibility studies on transportation infrastructure project sustainability?
4. What is the impact significance of the TIFS factors on transportation infrastructure project sustainability?
5. To what extent does the conceptualised TIFS model fit the data?

1.4.4 Hypotheses

The general hypothesis postulated in this study to be tested using the conceptualised model was that feasibility studies directly and indirectly affect the performance of transportation infrastructure projects while in operation. This related to the relationships as espoused from objectives GO2 to GO4. It was theorised that people and procedures play a meditating role in the relationship between feasibility studies and sustainability of transportation infrastructure. The direct and indirect effects between the feasibility study factors and project sustainable performance was therefore tested. The following broad hypotheses were postulated for testing using the SEM:

H1- Transport infrastructure feasibility study (TIFS) factors have a direct influence on the quality of feasibility studies;

H2 – The quality of feasibility studies has a direct influence on the sustainability of transportation infrastructure projects

H3 - Transport infrastructure feasibility study factors have a direct influence on the sustainability of transportation infrastructure projects

H4 - Transport infrastructure feasibility study factors have an indirect influence on the sustainability of transportation infrastructure projects, mediated by the quality of feasibility studies.

H5 – TIFS is a six-factor model comprising methods of appraisal, finance availability, planning data, user needs, local environment and strategic support.

1.4.5 Methods

A sequential exploratory multi-case mixed-method research process was adopted to achieve the objectives of the study. Figure 1 is a graphical representation of the research design adopted in the study. The method entailed a review of literature on feasibility studies and transportation infrastructure sustainability, as well as empirical data collection through document analysis, interviews and a field questionnaire survey. Multi-case studies through document analysis and interviews were used to elicit in-depth information on how feasibility studies were conducted. The qualitative enquiry focused on establishing how feasibility studies were conducted on selected projects and factors that were considered. A conceptual model was theorised based on the findings from the literature review and from empirical investigations. Thereafter, a questionnaire survey was used to amass quantitative data for validating the developed theoretical model and testing of hypotheses.

1.4.5.1 Literature review (secondary data collection)

The first stage involved literature review. The review was undertaken to inform the research and provide a background to the study. Databases available to the University of Johannesburg, related to the topic of study were searched. Various sources were consulted. These included journal, conference publications, reports, theses and dissertations. The literature was synthesised to identify relevant themes related to the objectives of the study. The emerging themes were then used to explore relevance, using transport infrastructure projects as case studies.

1.4.5.2 Pilot study (primary data collection)

Prior to the main study, a pilot study was conducted in November 2017. Unstructured interviews as well as a draft questionnaire, developed from the synthesis of literature and reviewed by the researcher's supervisors and statistician, for face validity, were pilot-tested. This face validity check ensured that the questions appropriately measured what they were supposed to measure. The draft questionnaire was also reviewed for simplicity and structure. The pilot study thus served to further identify complex or problematic questions in terms of structure and wording to eliminate misinterpretation during the main study.

1.4.5.3 Main study (secondary and primary data collection)

The research adopted a multi-case study strategy. The data for the multi-case study were collected using mixed methods (qualitative and quantitative), entailing document analyses, interviews and questionnaire survey. Questionnaires were used to collect quantitative data to establish the relationships, between TIFS model, quality and project sustainability. The unit of measure and analysis was transportation infrastructure projects.

Qualitative data collection

Document analysis (secondary data) and interviews (primary data) were used to achieve objective one, to identify how feasibility studies were conducted in terms of methods, processes and systems as well as performance of transportation infrastructure projects. Actual data on the feasibility study factors that were included in the planning of existing transport infrastructure projects, as well as data on actual performance of the projects was collected. Projects which had been in operation for more than one year were selected or the study since stable operational information/data could be obtained from those. Multi-cases (eight transportation infrastructure projects) were purposefully selected to include projects, which had been in operation for at least two years. The projects were identified from the Gauteng Province's Department of Roads and Transport (GPDRT), the City of Johannesburg (CoJ) and Johannesburg Roads Agency (JRA) in South Africa. Documents such as the Medium-Term Expenditure Framework (MTEF), Annual Reports, Annual Performance Plan, 25-Year Integrated Transport Master Plan (ITMP), feasibility and transportation study reports, and monitoring and evaluation reports were scrutinised. The convenient sampling approach was used because a database of transportation projects was available and accessible. In addition, purposive sampling was used to select projects, which had been in operation for more than two years. The selected projects' feasibility study information as well as monitoring/evaluation and performance reports were scrutinised.

Further, Built Environment professionals and transport stakeholders including financiers, investors, planners, feasibility study experts, and environmentalists that were involved in the planning of the projects as well as project managers and stakeholders involved in the management and operational activities of the transport projects were interviewed. The interviews sought to identify factors incorporated in feasibility studies as well as the processes, methods and structural systems employed in conducting the studies. The relevance or level of importance of these factors in feasibility studies was also sought. The interviews were audio-recorded for ease of transcription and analysis.

Quantitative data collection

Quantitative data collection included a field questionnaire survey (primary data). Questionnaires were employed for the purpose of collecting numerical data to establish significant relationships between the variables under consideration and to validate qualitative findings. A field questionnaire was developed using information (themes and content) obtained from the qualitative phase and literature review, following an initial pilot investigation. The questionnaire, sought information on the feasibility study factors and was administered to Built Environment professionals and transport stakeholders including financiers, planners, project managers, feasibility study consultants, environmentalists, safety officers, executive managers and directors.

Statistical information was thus collected together with rich descriptions of how feasibility studies are conducted and improved, to contribute to sustainability of transportation infrastructure projects.

1.4.5.4 Data analysis

Qualitative data analysis

Data from the document analyses and interviews were analysed using thematic embedded analysis. Transcribed interview data as well as feasibility study and performance reports were analysed using coding and content analysis, with the aid of Atlas-ti software for qualitative data analysis. This was in order to establish the presence of relevant *a priori* themes as identified from literature synthesis and pilot study. The emerging themes and concepts from the case studies were later integrated with the literature review findings, and thereafter used to develop statements for the quantitative enquiry that followed.

Quantitative data analysis

Empirical data from the questionnaires were analysed using the Statistical Package for the Social Sciences (SPSS), version 25 software to output descriptive and inferential statistics (exploratory factor analysis - EFA).

Descriptive statistics were used to determine the predominant factors incorporated and implemented during feasibility studies for transportation infrastructure projects. They were also used to examine and screen the data for tests of assumption for statistical input such as normality, outliers, and missing data. The descriptive outputs included mean, standard deviation, median and inter-quartile range scores.

Outputs from the inferential statistics (EFA) were common factors, which were refined, confirmed and validated in a subsequent confirmatory factor analysis (CFA). The EFA was used to reduce the number of variables in the sub-models, feasibility study quality, feasibility study elements (influencers) and project sustainability. The analysis of moment structures (AMOS) software version 25 was used to determine the measurement sub-models' fit to the sample data, as well as to validate the minimum number of variables related to each latent construct in the model, prior to structural modeling. The TIFS model was also evaluated. The structural equation modeling (SEM) was thereafter conducted to test the hypotheses postulated in the study.

The integration of both qualitative and quantitative results enabled intensive descriptions and rigorous statistical analyses of factors which influence the quality of feasibility studies and the influence of feasibility studies on the sustainability of transportation infrastructure projects. A graphical representation of the research process adopted in the current study is presented in Figure 1.1.

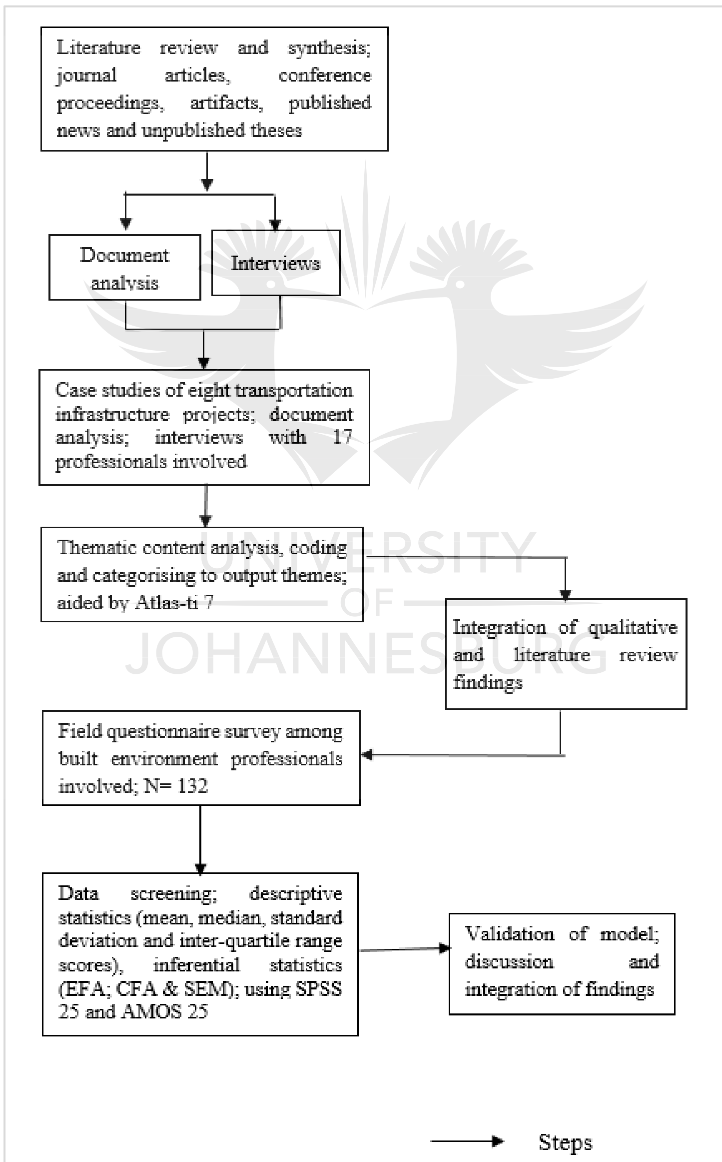


Figure 1.1: Sequential exploratory mixed-methods research design adopted

1.4.6 Results

Attempts to improve the sustainable performance of transportation infrastructure projects require an understanding of the feasibility studies that are conducted, and which factors are considered. The results of the current study therefore related to the relationship between transportation infrastructure feasibility study (TIFS) factors and project sustainability. The descriptive and inferential results are presented in tables, with accompanying descriptions in text.

Using data from the qualitative and quantitative phases, a model for transportation infrastructure sustainability was conceptualised and validated. This model with the significant relationships established, was presented as the final output of the current study.

The findings from the investigation were that the quality of feasibility studies was influenced by the transportation infrastructure feasibility study (TIFS) factors including appraisal methods used, finance and data available, user needs, strategic support as well as local environment and conditions. The results indicated that the people and processes depended on the degree to which the TIFS factors were incorporated in the feasibility studies. Additionally, the quality of feasibility studies was found to be predictive of project sustainability. Further findings yielded support for the theorised hypothesis between the TIFS model and project sustainability. The indirect effect of the TIFS factors on project sustainability was also statistically significant. The relationship was direct, as well and indicative of the fact that without adequate attention to the identified TIFS factors during the critical stage of feasibility studies, the sustainability of the projects in the long run, may be affected.

The results are envisaged to contribute to the understanding of how feasibility studies are conducted, what factors are critical to improve the quality of feasibility studies and subsequently, sustainability of transportation infrastructure projects. The output, which is the TIFS model, is expected to give confidence to would-be investors that their return is assured in view of the comprehensive feasibility study.

1.4.7 Scope

The study focused on factors that entail a comprehensive feasibility study. The impact significance of the factors was identified. The impact of feasibility studies on the sustainable performance of transportation infrastructure projects was also determined. A conceptual model of TIFS was developed, tested and validated for transport infrastructure planning. With a focus on transport infrastructure, the developed model revealed significant relations between feasibility study and sustainability of the projects.

The study included transport projects in the nine provinces in South Africa. All the nine provinces were included to enhance generalisability. Built Environment professionals and transport stakeholders including financiers, planners, project managers, feasibility study consultants, and environmentalists, safety officers, executive managers and directors, who were involved in the transportation projects in one way or another, were sampled using purposive and snowball sampling techniques. Transport projects, which had been in operation for more than one year were enrolled to the study.

The study included environmental sustainability of transportation projects in terms of compliance with regulations and legislations. It did not include greening. In addition, technical aspects of physical transportation infrastructure, such as modeling fragility and cracking, were not incorporated as variables from a structural engineering point of view. Furthermore, the study excluded in-depth review of energy conservation and greening principles as part of sustainability measures. Sustainability, in this study, simply connotes ‘the ability of a project to continue performing as was expected or projected over a long term, or throughout its life cycle (Bueno *et al.*, 2015).

1.4.8 Assumptions

The following assumptions were made in this study:

- Transportation sustainability is possible if a comprehensive feasibility study is conducted;
- The respondents were aware of the processes and procedures involved during the feasibility studies of the projects they reported on;
- The respondents were capable of responding to the research questions as they were considered to be knowledgeable and/or experienced on the subject; and
- The respondents provided honest information within the boundaries of their knowledge and experience

1.4.9 Significant contribution of the study

South Africa and indeed, the world, have long recognised infrastructure as being essential for economic growth (Palmer *et al.*, 2013). Infrastructure projects drive economic growth through job creation during the construction phase and better services with successful outcomes (Mabelo and Sunjka, 2017:40). Large infrastructure investments fuel economic growth by reducing cost of production and transport of people, goods and services, creating indirect positive externalities, increasing the productivity of input factors and smoothing the cycle of business (Ansar *et al.*, 2016:361). However, the performance of infrastructure investments (financial, social and environmental) is in fact strikingly poor (Ansar *et al.*, ibid.). Due to the poor performance of these investment projects, resources are being wasted as more of the projects are being built (Roxas *et al.*, 2015:82). Consequently, very intricate and influential problems, which could have been averted to a great extent in the planning of such risky endeavours, arise. Proficient planning and proper evaluation are needed to identify which projects comply with the demand forecast, cost forecast, and other projected impacts and thus resulting in improved decision making. The foregoing will result in projects that deserve to be built being delivered and those that do not, do not get built (Roxas *et al.*, 2015). Efficient planning is key in delivery of transport infrastructure, with long-term benefits, to safeguard economic growth.

Therefore, it is of paramount necessity to conduct research on ways to ensure that today's infrastructure investments can potentially serve future generations, while at the same time, quelling investors' concerns of uncertainties and assuring them of future positive performance or success of projects they decide to invest in. Success factors that should be considered during the critical stage of feasibility studies are indispensable to financiers and or investors who have to decide between alternative infrastructure investments in view of limited and or reduced resources.

The current study adds new knowledge on the impact of feasibility studies on sustainability of transportation infrastructure projects and also proposes a TIFS model, which is believed to be comprehensive. The study shows how the factors considered in a feasibility study can directly and indirectly shape the performance of transportation infrastructure during the operation stage. The findings contribute to the existing body of knowledge by identifying validated input parameters that contribute to comprehensive quality feasibility studies in order to ensure that the highly subjective process incorporates critical and often times uncertain variables, and the right people, in order to ensure a comprehensive and reliable appraisal and judgement.

In addition, the critical role of the quality of feasibility study, measured by the people and procedures involved, in ensuring sustainability, is revealed in the current study. The study lends support to previous studies on the subject of transportation project sustainability, but with particular contribution on the role of a comprehensive feasibility study stage in improving the quality of feasibility studies as well as the mediatory role of the processes and people involved in the feasibility studies, in achieving project sustainability, and thus the study makes a conceptual contribution in this regard.

Further, the use of robust research techniques including multi-case studies, a field questionnaire survey, exploratory factor analysis, confirmatory factor analysis and structural equation modelling. The use of the rigorous mixed-method research techniques to develop, refine, validate and test theory provided reliable and generalisable results. The significant transportation infrastructure feasibility factors should serve as a minimum number of factors to be targeted at when planning for transportation infrastructure projects, with a view to ensuring sustainability. The findings are envisaged to be beneficial to transportation infrastructure investors, policy makers and planners in deciding which projects will perform as expected and are worthwhile to invest in. In addition, it is envisaged that the findings will be useful to transportation infrastructure planners and decision makers in ensuring that valid and reliable assessments of risks and benefits are made at the time of transport projects planning. This would quell investors' concerns of uncertainties and thus assure them of the worthiness of the investment and future sustainability of the projects.

1.4.10 Ethical considerations

The participants were Built Environment professionals who were involved in the planning and feasibility studies of selected transportation projects, as well as project managers who had been involved in delivery of transportation infrastructure. The participants were interviewed and surveyed about the processes, methods, systems and data employed to conduct feasibility studies of particular transportation infrastructure projects. However, transportation infrastructure projects were the unit of measure and analysis.

Although the participants were not the unit of measure and analysis, the principles of social research in terms of autonomy, beneficence, non-maleficence and justice were upheld in the present study. Participants were not unduly influenced, induced, coerced or forced to take part in the study in any way. They were given the time and opportunity as well as any adequate information that they needed to decide whether to take part or not. They took part voluntarily.

The participants were fully informed about the research procedures involved and they gave their consent (written, in the case of interviewees) to participate. They were notified of their right to renege on their consent at any time during the study. The researcher strove to protect the sensitivity of information from the documents analysed. Consent to access sensitive information was obtained from the Heads of Departments in the government entities.

The participants were guaranteed anonymity and confidentiality (assurance that the information they provided in their responses were for research purposes only and would not be made available to anyone who was not directly involved in the study). Further, they were informed of the researcher's intention to audio-record the interviews and each participant's consent to audio-record the interview was sought before commencement. Prior to embarking on empirical data collection, an application to conduct the study, to the University of Johannesburg ethics committee, was done and upheld.

1.4.11 Resources

The study was made possible in part, by a scholarship from the University of Johannesburg through the Global Excellence and Stature scholarship award. The study further benefited from financial and material resources obtained from the Centre for Applied Research and Innovation in the Built Environment (CARINBE) in the University of Johannesburg. Additionally, the study benefited from exposure to national and international conferences. Resources from the University's large database of accredited academic journals were also beneficial. This study would not have been possible without these resources.

1.5 THESIS STRUCTURE

The thesis is presented in the following sections:

Introduction (Chapter One)

The background of the study, statement of the research problem, aim and objectives of the research, overview of the research design and methods, limitations, assumptions, and significance of the study are presented in Chapter one. The scope of the study and ethical considerations will also be presented in this section.

Literature review (Chapters Two and Three)

Chapters two and three present the concepts of sustainable performance of transportation infrastructure and feasibility studies, respectively. Additionally, the influence of feasibility studies on transportation infrastructure sustainability is discussed in Chapter three.

Research methods (Chapter Four)

The mixed methods employed in this multi-case study are discussed in detail in chapter four. The rationales for adopting specific techniques are expatiated on therein.

Findings from qualitative research (Chapter Five)

Chapter five presents the results from the qualitative research procedures including document analysis and interviews.

Conceptualised framework development (Chapter Six)

The framework developed based on the gaps identified from the literature review as well as the qualitative research is discussed in the sixth chapter of this work. The variables of the model, their relationships and the related postulated hypotheses are also presented in this chapter.

Results from quantitative phase (Chapter Seven)

Findings from the field questionnaire survey are presented in chapter seven.

Discussion of results (Chapter Eight)

Chapter eight presents a discourse on the findings from both phases, while integrating findings and comparing evidence of similarity or dissimilarity of findings from the two methods (qualitative and quantitative). These findings are also discussed with reference to extant literature.

Conclusion and recommendations (Chapter Nine)

The final chapter presents conclusions drawn from the findings in relation to the objectives of the research. In addition, it discusses the contribution of the study to research, policy and practice and presents recommendations made for further research, policy and practice.

1.6 CHAPTER SUMMARY

This introductory chapter presented the background to the study reflecting the need for the study, the aim, objectives, postulated hypotheses, research methods, ethical considerations, scope and limitations of the study as well as its significance. The background informed that the quality of feasibility studies prior to transport infrastructure developments is linked with its performance in the long run. The identification of factors of feasibility studies, which contribute to project sustainability provides evidence relevant to transportation infrastructure investors, planners and decision makers in assessing the viability of intended or proposed investments in the long run. In other words, the sustainable performance of projects in terms of being able to satisfy intended objectives throughout their lifecycle, is dependent on the factors considered during the feasibility studies. However, the quality of feasibility studies ultimately entails prescription and involvement of the right people and following the correct procedures to ensure that all factors, which should be considered are incorporated in feasibility study assessments.

Using an exploratory sequential mixed-method research design, the study also sought to investigate the relationship between feasibility studies and sustainability of transportation infrastructure projects. In the next chapter, the focus will be on the significance of transportation infrastructure as well as the problem of sustainability of transportation infrastructure, to highlight the need for the study.

CHAPTER TWO

TRANSPORTATION INFRASTRUCTURE PROJECT SUSTAINABILITY

2.1 INTRODUCTION

Insufficient or underdeveloped transport infrastructure presents one of the biggest obstacles for economic growth and social development worldwide (Beckers and Stegemann, 2013). When transport systems are deficient in terms of quality, capacity or reliability, they have an economic cost such as reduced or missed opportunities (Liyanage *et al.*, 2017). Moreover, transport infrastructure projects require substantial investments. An investor who has to decide among competing alternative investments requires assurance on the future performance of the subject project while in operation and indeed sustainability in the long run. In order to achieve this, it is necessary to understand the parameters upon which sustainable performance of transport infrastructure could be measured. Therefore, this chapter looks at and discusses on transportation infrastructure project sustainability concept.

2.2 TRANSPORTATION INFRASTRUCTURE SUSTAINABILITY

2.2.1 Defining the sustainability concept

The term "sustainability" has no universally accepted definition (Oswald and McNeil, 2010:178; Bueno *et al.*, 2015:623). However, as early as the ancient Egyptian, Mesopotamian, Greek and Roman civilisations, sustainability has been a concern and this was with regard to maintenance of the everlasting nature of the environment (Du Pisani, 2006:2). The concept was launched in 1972 at the United Nations Conference on the Human Environment (Bueno *et al.*, 2015). The World Commission on Environment and Development (WCED), in 1987, brought the concept to global prominence in the Brundtland Commission Report, and defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Hutchins and Sutherland, 2008:1688; Oswald and McNeil, 2010:178; Bongardt et al, 2011; Litman, 2016:7). The concept has gained popular momentum over the last 20 years and has been defined in different ways as well (Ahn and Kim, 2014). According to Ahn and Kim (2014), sustainability purports enabling all people to meet their basic needs and improve their quality of life, while ensuring that the natural systems, resources and diversity upon which they depend are maintained and enhanced, for both their benefit and that of the future generations.

The American Society of Civil Engineers (ASCE) defined sustainability as a set of environmental, economic, and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality or availability of natural, economic and social resources (Surbeck and Hilger, 2014:2080). Sustainable infrastructure is also defined by the ASCE as "…systems designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and (engineering) integrity (Stapledon, 2012:10). Infrastructure sustainability is the optimisation of a broad range of environmental, social and financial externalities on infrastructure projects (Palmer and Bishop, 2016).

The Centre for Sustainable Transportation, in 1998, defined sustainable transportation as one which:

> *"allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health and with equity within and between generations; it is affordable, operates efficiently, offers choice of transportation mode, supports a vibrant economy, limits emissions and waste within the planet's ability to absorb them, minimises consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise* (Oswald and McNeil, 2010:178).

The Federal Highway Administration opines that a sustainable transport infrastructure should satisfy lifecycle functional requirements of societal development and economic growth while striving to enhance the natural environment and reduce consumption of natural resources (United States Department of Transportation (USDOT), 2017). Transport infrastructure should be planned, designed, constructed, and maintained in a way that sustainably integrates environmental, community and society, and economic attributes effectively, sufficiently and successfully (Ramani *et al.*, 2009; Montgomery *et al.*, 2015:1). The goal of sustainable transportation is to ensure that environmental, social and economic considerations are factored into decisions affecting transport activity (Litman, 2011:3).

Other definitions of sustainability and sustainable transport development (Table 2.1) suggest that such infrastructure projects need to deliver its service efficiently and sufficiently throughout its life cycle. However, although these different views and definitions of sustainability and sustainable transport developments exist, there appears to be a consensus on the need to achieve economic and social development and protect the environment, that is, the three basic dimensions (Zavrl and Zeren, 2010:2952; Bueno *et al.*, 2015:622). Transport infrastructure sustainability connotes continuation of performance with regard to different aspects of life (economic, social, and environmental – the three bottom-line) on which such developments impact.

Table 2.1: Definitions of sustainability

	Definitions	**Source**
Sustainability	The capacity for continuance into the long-term future; ability to go on being done on an indefinite basis.	Litman (2016:7)
	Equity and harmony extended into the future, a careful journey without an endpoint, a continuous striving for the harmonious co-evolution of environmental, economic and socio-cultural goals.	
Sustainable development	Creating and maintaining conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations	Fitzpatrick et al. (2017)
	- Achieving a balance between several objectives (environmental, economic, and social) over dynamic time and spatial horizons - A land-use pattern characterised by growth and development occurring in a manner supported by infrastructure and financial resources, and proportional to the preservation of the current built and natural environments. - Aims to expand resources and improve QOL for as many as the heedless population growth forces upon the earth, and do it with minimal prosthetic dependence.	Litman (2016:7)

Table 2.1 (cont'd.): Definitions of sustainability

	Definitions	Source
Sustainable infrastructure	Infrastructure that: - Is planned, built, and maintained to provide services of adequate quality that promote sustainable and inclusive growth - Integrates environmental, social and governance considerations into project planning and development - Is socially, economically and environmentally sustainable	Mercer & Inter-American Development Bank (IDB) (2016:1)
Sustainable transport system	System that: - Allows basic needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations. - Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy. - Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles, minimizes use of land and production of noise.	Litman (2016:8)
	A system that allows basic access needs to be met safely and in a manner consistent with human and ecosystem health, with equity; is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy; limits the emission	Montgomery *et al.* (2015:2)

Nevertheless, although sustainability has been generally viewed and studied based on the three-dimensional aspects (environmental, economic and social aspects), transportation infrastructure sustainability entails a wider range of impacts beyond what is mostly studied (Stapledon, 2012). It incorporates the useful operational life of the assets since infrastructure projects need to deliver services over their lifetime, efficiently and reliably (Jeon *et al.*, 2010). Thus, technical or structural quality of roads, with regard to the quality and long-lasting nature of construction materials, in addition to quality of life, project leadership, natural resource management and climate change, have been studied as sustainability elements (Haas *et al.*, 2009; Ramani *et al.*, 2009; Zou *et al.*, 2011; Kaare and Koppel, 2012; Montgomery *et al.*, 2015). Further, the sustainability concept includes system effectiveness (which captures the concept of mobility/fluidity of movement) and performance over a long term (Jeon *et al.*, 2010). System performance is also related to its resilience and adaptability to changes, as supported by Stapledon (2012).

Furthermore, institutional sustainability is included as part of infrastructure sustainable performance (Spangenberg, 2002; Vera *et al.*, 2006; Brouwer and van Ittersum, 2010; Quium, 2014). In the course of evaluating the progress of implementing the United Nations Program of Action "Agenda 21", the Commission on Sustainable Development of the United Nations (UNCSD) defined sustainability as having four dimensions, namely, economic, social, environmental and institutional (Brouwer and van Ittersum, 2010:41). Institutional sustainability connotes the necessary institutional structure capable of delivering economic, social and environmental sustainability objectives defined during policy evaluations. This is especially important where multiple ministries, government departments and agencies at different levels of government are involved such as in the transportation infrastructure sector (Quium, 2014:45). Thus, the role of governments or institutions has to be added to the sustainability concept due to their critical role in transport planning and operations (Cottrill and Derrible, 2015:49).

The four sustainability dimensions are interlinked in such a way that their self-producing and non-linear capabilities need to be effectively managed in order to guarantee sustainability of transport infrastructure as shown in the prism in Figure 2.1. The implication therefore is that a clear distinction between and among economic, social, and environmental sustainability aspects or concepts is not always possible, since they overlap and interrelate (Litman, 2016). For instance, pollution is generally considered an environmental issue, but it also affects human health (social cum liveability issues) and fishing and tourism industries (economic issues).

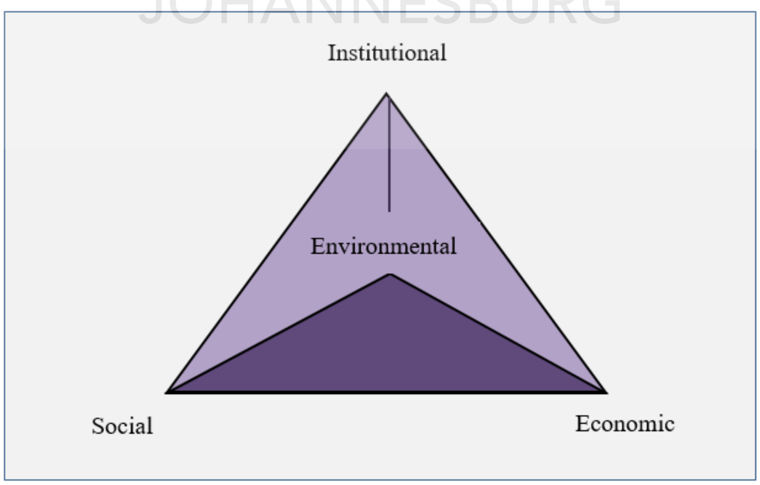


Figure 2.1: Four-dimensioned structure of sustainability (Spangenberg, 2002:105; Brouwer and van Ittersum, 2010:42)

Thus, integrating economic, social and environmental sustainability aspects can only be effective if proper institutional arrangements are in place in the respective countries (Brouwer and van Ittersum, 2010:42). However, political sustainability (intrinsically linked to institutional frameworks), to cater for government policies, representation and democracy, which are particularly problematic in Southern African countries, was also identified (De Carvalho, 2007; Palmer and Bishop, 2016).

More recent literature captured that sustainability can be defined as the ability of a project to maintain an acceptable level of benefit flows through its economic life or to maintain its operations, services and benefits during its projected lifetime (Muskin, 2017). Infrastructure sustainability is concerned with "'fit for purpose assets', where fitness is a function of an asset's capacity to be:

- continually useful over its entire life;
- a consistent and integral part of the wider infrastructure 'jigsaw', fulfilling community expectations by helping to solve sustainability challenges; and
- resilient and adaptable to changing circumstances (Stapledon, 2012:9).

Therefore, sustainability encompasses indicators that enable continual functioning and expected service over generations of users, without disrupting their quality of life of the citizenry. Since transport developments are intended to serve generations for a long time, such investments should provide assurance of lasting positive impacts and benefits that are continually and satisfactorily experienced for eons. This is especially important since sustainability for an investor includes environment, social and financial considerations (Palmer and Bishop, 2016).

In view of the above discourse, the synthesised definition for the current study is that sustainability is the ability of a project to maintain an acceptable level of services and benefit flows through its economic and operational life (Muskin, 2017). In Table 2.2, a summary of sustainability factors is presented. The economic, social and environmental factors are identified in most studies, while physical and institutional arrangements are identified in relatively few studies.

Table 2.2: Summary of broad sustainability concepts

Literature source	Year	Sustainability concept				
		Economic/ Financial	Social	Environmental	Physical	Institutional
Spangenberg	2002	X	X	X		X
Vera *et al.*	2006	X	X	X		X
De Carvalho	2007	X	X	X		X
Ramani *et al.*	2009	X	X	X		
Brouwer & van Ittersum (UNCSD definition)	2010	X	X	X		X
Jeon *et al.*	2010	X	X	X	X	
Oswald and McMeil	2010	X	X	X		
Zavrl and Zeren	2010	X	X	X		
Stapledon	2012		X		X	
Pearce, Ahn & HanmiGlobal	2012	X	X	X		X
ADB	2013b	X	X	X		
Hodges & Vaughn	2013	X	X	X		
World Bank	2013a	X	X	X		
Quium	2014					X
Surbeck and Hilger (ASCE definition)	2014	X	X	X		
Bueno *et al.*	2015	X	X	X		
Cottrill & Derrible	2015	X	X	X		X
Montgomery *et al.*	2015	X	X	X	X	
United Nations	2015	X	X	X		
Litman	2016	X	X	X		X
Mercer & IDB	2016	X	X	X		
Palmer & Bishop	2016	X	X	X		
USDOT (FHWA definition)	2017a	X	X	X		

2.2.2 Need for sustainability of transportation infrastructure

Transportation plays an essential role in countries' economic growth, competitiveness, balanced and livable spatial development, access to water and energy, and food security. Sustainability is also critical for social inclusion and improved quality of life (United Nations, 2015). The transportation sector primarily confers mobility and impacts on the development and welfare of the population through employment and income creation, connecting and providing to businesses and vital services, and therefore enhances economic development and growth (Friedrich and Timol, 2011; Chen and Cruz, 2012:136; Vilana, 2014:6; Faturechi and Miller-Hooks, 2015:1). Transportation infrastructure enhances economic growth, incites productivity where they are located and creates spillover effects to other regions. It creates favourable conditions for the location of businesses and economic growth, since they are implemented for ease of production of goods and services and their absence or poor quality thereof results in higher costs or impossible production (Randolph, 2016:247).

Further, transportation infrastructure contributes to the growth of an economy. It is estimated that a 10 percent rise in infrastructure assets directly leads to an increase in GDP by up to 1 percentage point (Beckers and Stegemann, 2013). It is also estimated that every dollar spent on a capital project, in utilities, transport, energy, waste management, or telecommunication, generates an economic return of 5% to 25% per annum (World Economic Forum, 2012). Further evidence suggests that investment in transport infrastructure and services, among other infrastructures, generates the highest returns in developing and transactional economies. Evidence from the construction and operation on the Gautrain project demonstrated that benefit (DBSA, 2012:132; Regan, 2017:8). Transportation infrastructure, together with other forms of infrastructure, is the foundation that connects a nation’s businesses, communities and people, drives economies and improves the quality of life. According to Schiff *et al.* (2013:29), demand for transport comes from households and businesses, and in most cases, transport is a complementary input to other activities of production of goods and services.

The importance of transport infrastructure is well noted in many studies (Vilana, 2014). The studies revealed that the transport sector and the mobility and link it confers impact directly on the level of economic output, employment, income, development and welfare of the population. Transport infrastructure can promote the regional economy if operated properly (Doke, 2015:1; Gulyás and Kovács, 2016:1723). It facilitates mobility of people and specialised products and services, which are essential for development and growth. Linked networks make the location of households, businesses and social activities more attractive and lucrative, and enhances the value of land and properties wherein provided (Brown-Luthango, 2011; Robbins, 2015). Changes in land use and employment opportunities also emanate from transport infrastructure developments (Bon, 2015).

According to van der Westhuizen (2007), transit is perceived as a means of overcoming developmental and amenity challenges based on spillover potentials such as the revitalisation of neglected urban precincts. Countries require a well-developed transport infrastructure to compete internationally and to provide a high level of accessibility in terms of traffic and goods flows (Schuckmann *et al.*, 2012:1374). Gautrain in South Africa, for instance, has pre-eminently buttressed SA to be a modern African State (van der Westhuizen, 2007:334). Therefore, the sustainability of transport infrastructure projects in terms of leveraging maximum possible funding from the available sources while preserving and maintaining existing assets for use by future generations has received a lot of attention for decades (Ramani *et al.*, 2009).

Therefore, poor sustainability of transportation infrastructure is detrimental to the immediate community, society and an economy as a whole. Project failure has dire consequences for all stakeholders involved. A country that has invested in a string of "white elephant" (non-viable albeit politically laudable) projects will end up in fiscal failure, unable to honour its debt liabilities, and with lost opportunities for GDP growth (Mabelo and Sunjka, 2017:41). Therefore, ways to sustain transportation infrastructure developments in order to keep benefiting from such investments throughout the desired life span, are worthy of continuous investigation.

Moreover, the nature of transportation projects, like most infrastructure, makes it rudimentary to attend to its sustainable performance. Transportation infrastructure investments are typically large and capital-intensive, involving vast amounts of resources in terms of time, money, labour, equipment and materials, and as such, are unpredictable and fraught with uncertainties (Hyari and Kandil, 2009:66; Regan, 2017:1). The uncertainties include cost estimation, schedule and return on investment and as such, the structuring and delivery of modern infrastructure projects is extremely complex (Beckers and Stegemann, 2013; Salet *et al.*, 2013:1984). These inherent complex attributes expose projects to international and domestic economic, social and political risks, which if not assessed and planned for at the early stages of the planning process, could lead to failure of projects (Mišić and Radujković, 2015; Mabelo and Sunjka, 2017).

The long-term character of transportation infrastructure projects requires that strategies, which appropriately match the uncertainty and huge variety of risks posed to the projects over their life cycles are developed to ensure achievement of objectives for which they are implemented in the first place (Beckers and Stegemann, 2013). Infrastructure projects are exposed to numerous risks including economics and revenue (Roxas *et al.*, 2015:82).

Therefore, given the importance and nature of transportation infrastructure projects (long-term character, uncertainties, risks and complexities), it is crucial that attention is given to its sustainability in the long run. This is important in order to sustain the project to deliver its intended objectives over the expected life cycle.

2.2.3 Sustainable performance of transportation infrastructure projects – An overview

Sustainability is affected by many factors. In the United States, the public and private sectors spent $125.7 billion on transportation in 2014 (USDOT, 2016:i). Despite the huge infrastructure spend, America's infrastructure was reportedly failing, with 11 - 12.1% of bridges (70,000 out of 607,380) deemed structurally deficient and in need of repairs or replacement, giving an indication that the objectives were not met (Columbia Broadcasting System (CBS), 2010; 2014).

In another example, a $50 billion investment program in new and upgraded land transport infrastructure across Australia was reported to deliver on safety (reduction of road trauma costs), relieving congestion and improving the liveability, connecting regional communities to markets and creating new jobs and business opportunities (Australian Government, 2016:3). However, expenditure on existing (operational) infrastructure is said to be much lower. This is despite the fact that much attention should be given to financial resources to sustain the project throughout its life cycle, in order to keep it in a state as to continue fulfilling the intended objectives.

In sub-Saharan Africa, poor road, rail and harbor infrastructure adds 30-40% to the costs of goods traded among African countries (Pottas, 2013:3). Without sustainable infrastructure, Africa would not achieve the growth levels expected or required. The objective of transportation infrastructure is that goods and services may be delivered efficiently. Therefore, when roads and other infrastructure are in poor condition, sustainability is compromised.

In South Africa, the transport sector is a key contributor to the country's competitiveness in global markets (Doke, 2015:1). South Africa continues to have a relatively robust, extensive and functional transport infrastructure network when compared with neighbouring countries (Republic of South Africa, 2018). However, there are problems manifesting in challenges emanating from financial, institutional, physical and human frailties (Lombard *et al.*, 2017). The transport sector is especially hobbled by poor road safety, ranking 42nd highest in road mortality rates in the world, with 25.1 road deaths per 100,000 people (Writer, 2016).

The performance of transport infrastructure is generally stymied all over the world, being mainly characterised by poor road safety, inefficiency and maintenance problems, and South Africa is no different. The transport sector has been characterised and riddled with inter-modal inherited and/or acquired problems such as poor maintenance, institutional capacity deficiencies, unresponsive demand, escalating costs (for capital and maintenance), inadequate finance, and outdated and/or inaccurate information. In the current study, it is argued that some of the problems and challenges encountered in the operational stage of transport infrastructure projects could be mitigated by according considerable attention to how feasibility studies are conducted and the factors that may contribute to desirable outcomes. The study argues that the performance of transportation infrastructure projects can be sustained if attention is given to conducting and delivering a comprehensive and quality feasibility study, which would lead to developing robust strategies to overcome or mitigate the risks' impact.

2.2.4 Assuring transport infrastructure sustainability

Assurance means "a positive declaration intended to give confidence"; ability to inspire trust and confidence about something (De Jager and Du Plooy, 2007:100). It entails planned and systematic actions necessary to provide confidence that a facility will perform satisfactorily in service (Babu *et al.*, 2017:167). It also connotes activities to ensure that a project will employ all processes needed to meet requirements (Simona *et al.*, 2010:140). Thus, assurance of infrastructure sustainability means putting measures in place to guarantee better and lasting performance.

Given the long-term nature of infrastructure investments, assuring sustainability is critical (Hristova, 2015; Egler and Jurik, 2017). Achieving sustainability in infrastructure delivery is driven by financial imperatives, gaining public acceptability for projects and enhancing relationships with internal and external actors by demonstrating due diligence on social and environmental issues (Scanlon and Davis, 2011:122). Sustainability, in terms of stability of cash flow, environmental, social and physical infrastructure performance through the entire economic cycle is therefore crucial (Pojani and Stead, 2015).

Sustainability in infrastructure development enables sound economic development, job creation and productivity; enhances quality of life; and promotes a more efficient and effective use of financial resources (investors' margins) (Montgomery, 2015). Failure to address sustainability risks is likely to result in long-lasting and potentially irreversible impacts on wellbeing, health and the economy (Bhattacharya *et al.*, 2016:7). It is possible to plan infrastructure that manages any potential negative impacts while enhancing positive benefits and assuring investors, developers and policy makers of returns and expectations such as transparent procurement practices, risk-adjusted returns, availability of co-financing and risk-sharing, tenure, and so on.

Literature posits that sustainability of infrastructure is hampered by lack of finance, governance and policy problems, planning inefficiencies and technical capacity (Simona *et al.*, 2010; World Bank, 2013b; 2014a; Bueno *et al.*, 2015). Thus, for projects to be sustainable, there are key elements or conditions which must be extant. These include planning (efficiency), plans, control and management (strong institutional structures and governance) (Mercer and IDB, 2016).

Good planning and plans ensure that factors that may constitute risks are investigated and mitigation measures are put in place to reduce the impacts. In addition, good planning ensures that effective financing structures that make it possible to realise the scale and quality of investment in sustainability on a given infrastructure project are put in place (World Bank, 2013b; Bhattacharya *et al.*, 2016:7).

Other conditions for sustainability include control and management. Control and management has to do with governance and institutional structures that ensure that processes are followed, and the overall portfolio performance of infrastructure is improved and sustained (OECD, 2015:1). Good governance is also a necessary condition for sustainable infrastructure delivery since it enable provision of the right infrastructure in a cost-efficient, legitimate and affordable manner (OECD, 2015). The key to mobilisation of funding and financing of sustainable projects is a combination of better and more stable sectoral policies at the national level, appropriate risk-sharing instruments, and relationships between actors. These can help lengthen investor horizon and strengthen investor confidence (Bhattacharya *et al.*, 2016).

Infrastructure projects with deficient governance, a product of front-end planning, often result in cost overruns, underperformance, underutilisation, accelerated deterioration and occasionally, expensive "white elephants" and bridges-to-nowhere (OECD, 2015:1). Weak institutional capacities and national infrastructure plans do not usually allow local entities to effectively finance or maintain infrastructure projects (Bhattacharya *et al.*, 2016). This leads to slow response to maintenance and operational needs and thus deterioration of infrastructure (Mercer and IDB, 2016). Weak national infrastructure plans and cumbersome planning machinery also create major costs for investors and developers and exacerbate problems of corruption. Good institutional structures also ensure that implementation of responsive and integrated information systems that complement infrastructure demand and management are extant during the operational stage.

Furthermore, development of institutional capacity is essential as scarcity of skills hampers realisation of sustainable projects. Weak project development capacity translates into fewer bankable projects and much higher levels of risk (United Nations Economic Commission for Africa (UNECA), 2017). Skills to develop bankable project, mobilise funding, establish legal frameworks and allocate risk in a conducive and acceptable manner (to all stakeholders) are critical if sustainability is to be achieved (World Bank, 2013b). Developers and concessionaires who have the sophistication to manage complex, multi-stakeholder, technologically demanding infrastructure projects are critical if sustainability is to be achieved (Bhattacharya *et al.*, 2016:13).

Generally, there is an acknowledgement that strong due diligence, which should include environmental, social and governance factors tends to reduce risk and therefore increases certainty of outcomes from infrastructure investments (Mercer and IDB, 2016:7). Therefore, for sustainability, these elements must be covered or incorporated in the feasibility studies. Great potential reductions in sustainable impacts at the operational stage could be made if sustainability is considered at the early planning stage (Bueno *et al.*, 2016:625). Incorporation of sustainability criteria (social, economic and environmental elements) of infrastructure projects at the beginning of the development process helps to mitigate risks and reduce costs as mitigation measures are identified early on and potential sustainability is assured (Egler and Jurik, 2015; Bhattacharya *et al.*, 2016). Hence, inclusion of sustainability principles at the decision-making stage helps investors, developers and policymakers to make decisions about the future sustainability performance of the projects (Bueno *et al.*, 2015:625).

Suffice to say that assuring sustainability in infrastructure development entails an assessment of conditions necessary to attain desired sustainability goals or outcomes. Thus, at the planning stage, studies carried out to determine the feasibility and viability of projects should include elements of sustainability (Dong *et al.*, 2018). This is especially important since an understanding of what sustainability means on a project allows for focus and promotion of specific measures for the pursuit of sustainability as well as prioritising of measures. However, these must be based on the need, potential risks and opportunities (Scanlon and Davis, 2011; Yang *et al.*, 2015).

Consequently, different sustainability assessment tools and frameworks have been advocated and used to ensure that uncertainties and favourable structures are incorporated in feasibility assessments in order to eliminate or reduce uncertainties and increase confidence in transport infrastructure investments. Some of these assessment methods include:

- Capacity analysis (Ghosh et al, 2013:441);
- Analysis of strengths, weaknesses, opportunities and threats (SWOT) (Warren *et al.*, 2015:138; Blanco and Moudon, 2017:4692);
- Environmental impact assessments (EIA) (Galmarth *et al.*, 2014);
- Scenario planning (Liu *et al.*, 2015: 194; Blanco and Moudon, 2017:4692);
- Cost-benefit analysis (CBA) Flyvberg *et al.*, 2014; 2016);
- Reference class forecasting (RCF) (Flyvberg *et al.*, 2014; 2016);
- Multi-criteria analysis (Bueno *et al.*, 2015:628); and
- Life cycle assessment (LCA) (Bueno *et al.*, 2015:631).

However, some of the above methods have problems with incommensurability and bias, like the CBA, and do not really predict or measure "impact" (Liu *et al.*, 2010; Siemiatycki, 2010: 30; Jones *et al.*, 2014:402; Bueno *et al.*, 2015:623). The EIA, MCDA and SWOT, on the other hand, are considered to be subjective, inconsistent and rigid (Douthwaite, 2007:9; Bueno *et al.*, 2015:628).

Other sustainability assessment tools are standardised frameworks and rating systems, which focus on system characteristics and mainly environmental sustainability issues. Some of these sustainability and performance measurement systems include:

- Civil Engineering Environmental Quality Assessment (CEEQUAL);
- Infrastructure rating and recognition system) (Envision^{TM});
- Leadership in Energy and Environmental Design (LEED);
- Green Leadership in Transportation Environmental Sustainability rating program (GreenLITES)
- Illinois Livable and Sustainable Transportation (I-LAST);
- Infrastructure Voluntary Evaluation Sustainability Tool (INVEST);
- European Foundation for Quality Management;

- Link and effect model; and
- Environmentally and Economically Sustainable Transportation-Infrastructure-Highways (BE2ST-in-Highways™) (CEEQUAL, 2007; Zavrl and Zeren, 2010:2955; Stenström, 2014:21; Upadhyaya, 2014:486; Bueno *et al.*, 2015:623).

Nonetheless, while these conventional sustainability assessment tools and models attempt to accommodate uncertainty through providing a range of forward projections, they have a reputation for being based upon historical trends and relationships leading to extrapolation and bias (Lyons and Davidson, 2016:105). Despite their usefulness, these tools and methods tend to conceal uncertainty, with their quantifications giving an air of precision and authority. However, the methods have been proven to be fallible. Moreover, they are biased towards either an environmental, or an economic assessment and therefore fail to fully address all components of sustainability holistically (Bueno *et al.*, 2015). They are thus not really designed to assist investors when selecting the most worthwhile projects for sustainable investment, considering the plethora of uncertainties with which infrastructure investments are fraught.

Suffice to say, a wider array of impacts that go beyond those directly affecting users of transport facilities or services influence sustainability of transport infrastructure. Thus, transport planning and investment should consider more impacts and options in order to find the optimal alternative with maximum returns or benefits (Litman, 2016:18). Particularly, variables that reflect sustainability holistically should be incorporated no matter how difficult they are to measure (Cervero, 2011; Montgomery *et al.*, 2015:3). It is paramount that tools used to assess infrastructure risks at the planning stage incorporate consideration of how and where sustainability features impact the quality and life of a subject project. Thus, addressing these issues at the planning stage through feasibility studies, to demonstrate more competitive risk-adjusted returns and long-lasting viability, is critical.

In summary, it is unlikely that sustainability of transport infrastructure projects will be attained if the factors which affect the long-lasting serviceability and returns from the investment are not considered at the planning stage. In other words, analyses conducted at the planning stage (feasibility studies) should incorporate sustainability elements. Therefore, the argument is that the sustainability outcome of projects depends on the feasibility studies conducted at the time of decision making to invest. However, the question is, “how is sustainability measured in infrastructure projects?”

2.2.5 Transport infrastructure sustainability indicators

The terms “indicator” and “measure” both refer to variables and with regard to performance, they help to assess progress (Ramani *et al.*, 2009:9). Indicators are measures that provide specific information about the properties or attributes of a system (Cottrill and Derrible, 2015:47). They translate data and statistics into succinct information that can readily be understood and can be used to track a system’s performance or achievement of results (Ramani *et al.*, 2009:9). Performance indicators relate to how well a system is meeting its goals and objectives. Therefore, performance indicators can be used to measure or evaluate transportation infrastructure sustainability (Ramani *et al.*, 2009:12; Dhingra, 2011:2). A distinction has, however, been made between the terms “performance indicator” and performance measure” in the sense that an “indicator” refers to a variable used in monitoring performance, which becomes a “measure” when compared to standard or benchmark values; but they can be used interchangeably (Ramani *et al.*, 2009).

A review of literature shows that a cornucopia of infrastructure sustainability indicators exists in different contexts and sectors. Key characteristics, which indicators should possess include representativeness, relevance, policy sensitiveness and predictability, to cater for the complexity of factors that must be considered in infrastructure sustainability (Cottrill and Derrible, 2015). In order to be effective, the indicators should also reflect local conditions, be practicable and feasible to adopt in practice as well as be acceptable by local actors (Zavrl and Zeren, 2010; Dhingra, 2011; Schiff *et al.*, 2013).

Sustainability indicators evidenced from the rating systems, listed in the previous section, revealed mainly environmental preservation measures, with the exception of GreenLITES and INVEST, which include community impacts, health and safety, efficiency, financial sustainability, infrastructure resilience, economic development and land use, multi-modal transport, accessibility, affordability, travel demand, and pollution (CEEQUAL, 2007; Hodges and Vaughn, 2013; Bueno *et al.*, 2015). However, most of the rating systems are usually regionally based and incorporate context-sensitive sustainability elements of the location where they were conceived (Bueno *et al.*, 2015:635). Thus, it is necessary to review and identify specific factors used to measure sustainability in related infrastructure sectors, to be within a specified context.

Other sustainability indicators include productive life, percentage emissions, efficiency, project internal rate of return (IRR), expenditure, capacity, affected or preserved natural environment, pollution levels (air, water and noise), community, and safety performance (Shortall *et al.*, 2015; Sharma and Strezov, 2017). In addition, accessibility, reliability, affordability, pricing, taxing and subsidies, (Vera *et al.*, 2006), as well as pollution, land preservation, consumption levels, efficiency and institutional frameworks are all considered to be critical (Vera *et al.*, 2006). Acceptability is another indicator of sustainable infrastructure as shown in Valentin *et al.* (2012), in which the level of opposition was investigated for delivery of a nuclear power plant.

Additionally, physical condition, capacity to meet demand and replacement value in dollars (funding versus need), repairs and replacement of aging infrastructure and non-compliance with existing and future federal water regulations were used to assess water and stormwater infrastructure sustainability (Upadhyaya *et al.*, 2014). Further, service quality, affordability, financial performance, and institutional capacity, network performance and usage versus demand have been identified (World Bank, 2014b). Reliability, resilience and vulnerability, life cycle costs for maintenance, energy consumption and recovery, and environmental impacts (Dong *et al.*, 2018:331) as well as asset management efficiency viz-a-viz customer satisfaction (Han *et al.*, 2015) are also considered as infrastructure sustainability indicators. Additionally, the level of public opposition and acceptability is an important sustainability measure. The construction of the Nicaraguan canal, where perception studies were necessary to identify the future acceptance and value of the canal weighed against preservation of the natural habitat, demonstrated the importance of public opinion (Erlich, 2015; Kraul, 2015).

Sustainability indicators in the transport infrastructure sector also include social, economic and environmental elements as well as institutional factors. A sustainable transport system satisfies functional requirements, fulfils transport goals and needs, addresses development and economic growth and reduces environmental and resource consumption impacts (Hodges and Vaughn, 2013:4). It is universal, efficient, safe and environmental friendly (Vandycke, 2015). It includes aspects related to accessibility, mobility, reliability, asset value, comfort and convenience, operational efficiency and effectiveness, positive public acceptability, and socioeconomic conditions (boosting local productivity) (Ramani *et al.*, 2009; Montgomery *et al.*, 2015:3). Greenhouse emissions, congestion, accidents and pollution are also reflective of transport sustainability (United Nations, 2015). Likewise, Haas *et al.* (2009) found that safety, mobility and speed, reliability, environmental protection, productivity, user benefits, asset value, comfort and convenience, program delivery, operational efficiency were measures of road sustainability performance in international practice. Furthermore, reliability and aquatic biodiversity protection were captured as waterway (port) infrastructure sustainability indicators (World Bank, 2018). In addition, uptake of transport (demand) and travel experience (including comfort) (World Bank, 2011) as well as efficiency and institutional frameworks (Barnes-Dabban *et al.*, 2017) were identified as port infrastructure sustainability measures.

In summary, sustainability indicators usually include environmental, economic and socio-cultural factors, as presented in Figure 2.2 (Jeon *et al.*, 2010:228). However, Cottrill and Derrible (2015) and Litman (2016) argued that institutional and physical factors are also important aspects of sustainability and should also be considered during the planning of transportation infrastructure.

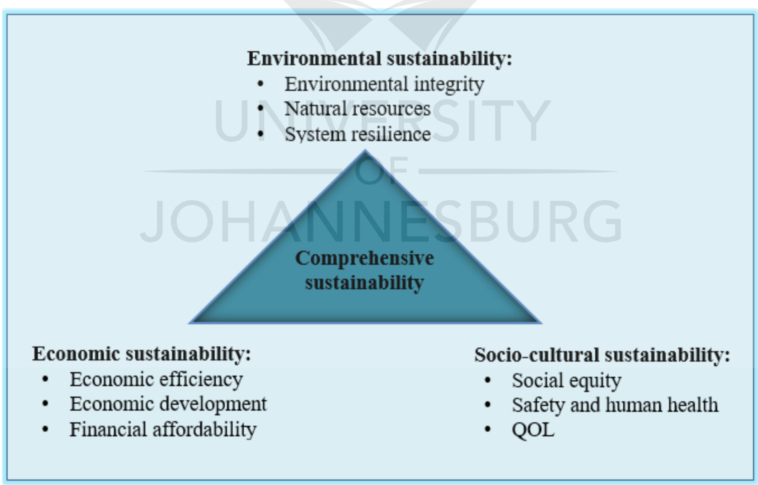


Figure 2.2: Transport **s**ustainability dimensions and indicators (Source: Jeon *et al.*, 2010:228)

The reviewed literature identified key sustainability indicators as summarised in Table 2.3. The factors were observed to be common to most studies. However, due to the cornucopia of sustainability connotations and indicators, which exist, some of the measures have been merged for simplicity and practical use as well as relevance of the model to the objectives being considered (Zavrl and Zeren, 2010; World Bank, 2011; Cottrill and Derrible, 2015).

Table 2.3: Summary of sustainability indicators

	Financial & Economic				Social				Environmental		Physical infrastructure		Institutional		
	Adequate funding	**Affordability**	**Demand**	**Commerce/productivity**	**Accessibility**	**Safety & security**	**Experience/satisfaction**	**Acceptability**	**Pollution**	**Environmental preservation/protection**	**Quality/standard/condition**	**Reliability (functionality, connectivity, capacity, resilience)**	**Service quality /operational effectiveness & efficiency**	**Clarity of responsibilities**	**Technical capacity & incentives for operations and management**
Ugwu & Haupt (2005)		X				X	X			X		X			X
Vera *et al.* (2006)	X		X		X	X			X	X		X			
De Carvalho (2007)	X	X	X		X				X	X			X	X	X
Haas *et al.* (2009)				X		X	X			X		X	X		
Ramani *et al.* (2009)				X	X		X			X	X	X	X		
Jeon *et al.* (2010)		X		X		X	X		X	X		X	X		
Oswald & McNeil (2010)		X		X	X	X			X	X			X		
USCC (2010)						X					X		X		
World Bank (2011)		X	X		X		X					X	X		
VanZerr & Seskin (2011)				X			X			X					
Akadiri *et al.* (2012)	X			X			X		X	X	X	X			
Grant *et al.* (2012)							X	X							
Karlaftis & Kepaptsoglou (2012)					X	X							X		
Stapledon (2012)							X				X	X	X		
Valentin *et al.* (2012)								X							
ADB (2013b)		X			X	X				X					
Hodges & Vaughn (2013)				X	X					X		X			
Luke& Heyns (2013)					X		X	X				X			
NLC (2013)				X			X			X					
World Bank (2013a)	X	X				X			X			X	X	X	X
Upadhyaya *et al.* (2014)	X										X	X	X		
World Bank (2014b)	X	X			X						X				X
Carter (2015)								X						X	X
Cottrill & Derribe (2015)	X				X	X			X		X		X		X
DoT (2015)											X	X			
Erlich (2015)								X							
Han *et al.* (2015)							X								
Kraul (2015)								X							
Mišic & Radujković (2015)								X					X		

Table 2.3: Summary of sustainability indicators continued

	Financial & Economic				Social				Environmental		Physical infrastructure		Institutional		
	Adequate funding	**Affordability**	**Demand**	**Commerce/productivity**	**Accessibility**	**Safety & security**	**Experience/satisfaction**	**Acceptability**	**Pollution**	**Environmental preservation/protection**	**Quality/standard/condition**	**Reliability (functionality, connectivity, capacity, resilience)**	**Service quality /operational effectiveness & efficiency**	**Clarity of responsibilities**	**Technical capacity & incentives for operations and management**
Montgomery *et al.* (2015)				X			X			X	X		X		
Shortall *et al.* (2015)	X					X	X			X		X			
UN (2015)	X					X			X	X				X	
Vandycke (2015)					X	X				X			X		
GoS (2016)		X								X	X	X			
National Geographic (2016)							X								
Barnes-Dabban *et al.* (2017)										X			X	X	X
Pattinson (2017)										X	X	X	X		
Sharma & Strezov (2017)					X					X	X	X			
World Bank (2018)										X		X			
Asongu *et al.* (2018)									X		X	X			
Dong *et al.* (2018)	X		X									X			
World Bank (2018)	X	X			X	X			X						

2.2.5.1 Financial and economic factors

One of the key issues is adequacy of funds. Adequacy of funding or financial sustainability of infrastructure deals with sufficient funds to cover the invested capital and cash income accrual to an investor. It also entails costs of administration and expenditure to maintain, expand, repair or replace capital infrastructure facilities to required standards, over the life cycle of the infrastructure (World Bank, 2013).

In Liyanage *et al.*'s (2015) view, adequacy of funding has to do with availability of finance when needed, sufficient cash flow for expected payments to all parties, and expected (or better than anticipated) financial reward for the investor or private partner. Literature also posited that "adequacy" with regard to the "expected" payback period (in addition to the amount) is an indication of good performance because for an investor, who expects to receive concessions (periodic payments) over a specified period, they are somewhat certain and confident about financial security and steady income over the period (Waghmare and Pimplikar, 2012:3167).

Continuity and security of funding for asset maintenance is crucial because without due attention to the physical infrastructure, the services and structures will eventually deteriorate (Pinard *et al.*, 2016; World Bank, 2013a:27). Timely maintenance therefore saves long-term costs.

Apart from adequacy, the question of affordability by users is equally important. Affordability, which has to do with ability to pay transport bills, taxes, tickets, and other charges has been classified as a social factor in some studies (World Bank, 2013:26; Litman, 2016:3) and as an economic aspect in others (Jeon *et al.*, 2010). However, in the current study, it is classified under the financial and economic factors because it is monetary in nature and involves parting with funds in order to fulfil a need (economic).

Affordability on the part of the users is related to demand. Demand is the amount of mobility and transport options, which consumers/users would choose at a given time (Jeerangsuwan *et al.*, 2014). Traffic demand sustainability is critical because it is associated with revenue. Revenue from the traffic volume is almost the only source of capital recovery and profits from investments (Jeerangsuwan *et al.*, 2014; Okoro *et al.*, 2016). Traffic demand is an essential aspect of road performance and sustainability. This is especially so where a private investor is involved in ownership and/or operation and management of the road infrastructure system and facilities (Mišic and Radujković, 2015).

The built transportation infrastructure should include spin-off benefits such as increased commerce. For example, increase in jobs, businesses and revenue as a result of existence of the infrastructure guarantees sustainability (Ramani *et al.*, 2009:12). Facilitating trade and economic opportunity is one of the specific goals of transportation sustainability (Ramani *et al.*, 2009:14).

Transportation infrastructure should sustain wider economic benefits such as local businesses, tourism or agriculture.

2.2.5.2 Social factors

Transport infrastructure systems should fulfil the basic expectation and need of access to work, education, shopping, health care etc. It should provide access for all citizens irrespective of income, location, or personal situation, that is, inclusive mobility (World Bank, 2013a:26; 2018). Accessibility is defined in terms of ease of getting to the transport facility from the most remote location within the catchment area (World Bank, 2011:14). Accessibility is key and should be accompanied by safety.

Safety and security are key concerns globally. Urban transport needs to be safe and secure; not just at the point of use but at all times, as well as for the disabled (World Bank, 2013a: 27). They have to do with feeling of safety from accidents and injury, personal security from crimes such as thefts, harassment, assault as well as existence of safety management programs (Dhingra, 2011:28; Karlaftis and Kepaptsoglou, 2012; World Bank, 2013a:16). Infrastructure use or demand drops with the feeling of being unsafe while using the infrastructure. This is in turn related ot the level of satisfaction obtained from the infrastructure usage.

User satisfaction is an important aspect of sustainability and performance of the infrastructure. It is related to the quality of services provided by the infrastructure system (Dhingra, 2011). There is need to incorporate the views of road users and perception on quality, which are typically and largely ignored or neglected especially in infrastructure performance assessments (Dhingra, 2011:15; Hartmann and Ling, 2016). Moreover, considering that the services provided are meant to be paid for, the users' satisfaction and experience are important considerations in performance measurement. Research further suggest that the experiences from transportation characteristics and traffic conditions have influence on the ease of traveling (Hartmann and Ling, 2016:29; Ettema *et al.*, 2013). Therefore, perceived level of satisfaction from services (such as security and delays) can be used to measure performance, even as a stand-alone measure (Canterelli *et al.*, 2010; Liu *et al.*, 2015, Mišic and Radujković, 2015; Carter, 2015; Hartmann and Ling, 2016; Liepziger and Lefevre, 2015; Liyanage and Villalba-Romero, 2015; Osei-Kyei and Chan, 2016). According to Redman *et al.* (2013) and Pavlina (2015), performance indicators for customer satisfaction include overall journey experience, customer service, maintenance of vehicles (for public transport), personal safety, safety of vehicles and facilities at motor parks/stops, comfort and convenience of rides, cleanliness, accessibility, frequency and punctuality of rides, complaint handling, effective complaint resolution, response to emergencies, satisfaction with road system condition and the number of complaints in total.

In total, the level of acceptability or opposition to a project from the public will most likely reflect performance. Equally, the level of acceptability of a project by the public is reflected by the willingness to pay a set fee or tariff for the use of the infrastructure; number of complaints at a given point in time; and level of opposition to proposed developments and/or pricing mechanisms, charges, and traffic/vehicle restrictions (Canterelli *et al.*, 2010; Liu *et al.*, 2015, Mišic and Radujković, 2015; Carter, 2015, Liepziger and Lefevre, 2015; Pojani and Stead, 2015; Osei-Kyei and Chan, 2016).

Willingness to pay and attitude towards pricing mechanisms or charges reflects the value attributed to a particular transit or transport option (Beria *et al.*, 2018). For instance, how much will consumers be willing to pay for a new road or improvements in capacity to decongest travel routes? Willingness to pay is in turn associated with the benefits from using the facility, level of services, income of users and resulting demand (Alasad *et al.*, 2012; 2013; Mišic and Radujković, 2015; Pojani and Stead, 2015). For instance, the level of fee charged for the use of the service (toll charges) might negatively affect users' willingness to pay, which reduces the demand (Alasad *et al.*, 2012; 2013).

Public acceptability is reflected in the level of public complaints and opposition (Valentin *et al.*, 2012; Carter, 2015; Erlich, 2015; Luke and Heyns, 2013; Mišic and Radujković, 2015; National Geographic, 2016; Rwelamila, 2016). An example is found in Mišic and Radujković's (2015) study where that public opposition to the development of the Lignes a` Grande Vitesse Me´diterrane´e in Paris resulted in the passing of a statute to ensure that there is public debate about future infrastructure developments at the time of decision to build. The first Sub-Saharan Africa's road PPP was considered successful partly because it was accepted by the population (Carter, 2015). In Kenya, a new railway corridor under construction threatened wildlife and attracted opposition from conservationists (National Geographic, 2016). Likewise, in South Africa, protests regarding the e-toll road network in Gauteng (Rwelamila, 2016) and service delivery with regard to public transport (Luke and Heyns, 2013) reflected lack of acceptability. Acceptability leads to increased demand for the transportation infrastructure services and assurance of liquidity especially in cases where an investor depends on the traffic demand outcomes and resultant benefits accruing thereof (Mišic and Radujković, 2015).

2.2.5.3 Environmental factors

Environmental quality is measured by how much fuel is used and pollution produced by transportation operations (including traffic noise exposure and emissions from vehicles) (Coffey and Fahrig, 2012; Grant *et al.*, 2012; Litman, 2016). Environmental sustainability is usually concerned with air quality from atmospheric levels of carbon monoxide, nitrous oxides and particulates from transport generated emissions) and noise levels (not exceeding norms of 55 decibels during the day and 45 at night) (World Bank, 2013a).

However, it is hard to prove or measure how much impact transport developments have on air quality since other developments such as building construction, mining and industrial emissions, also play a role in altering the level of pollution in the air in a given period and air pollution is not restricted by geographical boundaries; it travels long distances and across state lines (Enslin, 2007; Razak *et al.*, 2013:176). However, efforts should generally be made to reduce pollutants (air, water and noise) (Zhou, 2012).

Environmental sustainability is concerned with preservation of natural environments, proportion of green area preserved, welfare of wildlife, percentage of investment in environmental protection, and so on (Ramani *et al.*, 2009; National Geographic, 2016). Environmental sustainability also includes efficacy of monitoring and evaluation policies as well as programmes put in place to ensure that the infrastructure’s impact is controlled (Karlaftis and Kepaptsoglou, 2012). Monitoring and evaluation of policies is critical to ensure risk-adjusted returns on infrastructure investments and environmental protection simultaneously. These have to do with the institutions responsible for implementing planned mitigation measures to control air and noise pollution as well as landscape preservation. These in turn ultimately affect the rate of yield benefits or impose negative impacts that may indeed contribute to net losses (Wang *et al.*, 2018).

2.2.5.4 Physical infrastructure factors

Good quality infrastructure leverages the optimum possible funding for an investor as people will be willing to pay for its use (Ramani *et al.*, 2009; Alasad *et al.*, 2012; 2013). On the contrary, poor quality infrastructure is detrimental to an investor as it results in low demand for services provided by the development (Pregnolato *et al.*, 2017:68). Infrastructure deteriorations and deformations are in the form of rutting, poor drainage facilities, waterlogging on pavements (with regard to road and airports), unevenness (of roads and railways) and so on (Mukherjee, 2014:44; Hartmann and Ling, 2016:34).

The quality or condition of infrastructure dictates the level of reliability the development can offer. Reliability is defined as the ability of fulfilling a function successfully, meaning that the "system is in a condition to be able to accomplish a predetermined function during a prescribed period of service (Nagae and Wakabayashi, 2015:156). For transportation infrastructure such as roads, it has to do with connectivity, travel time, and capacity reliabilities (Dhingra, 2011:28; VanZerr and Seskin 2011; Grant et al, 2012; Nagae and Wakabayashi, 2015:156). Connectivity is concerned with the probability that the nodes remain connected. Travel time represents the probability that a trip can be made successfully within an anticipated time. Capacity reliability can be defined as the probability that the network can accommodate a given amount of traffic demand at a required level of service (Kuang *et al.*, 2013:1819). Capacity is related to functionality, which is the ability of the infrastructure to cope with greater volumes of traffic, that is, the infrastructure's bearing capacity year in year out (Fancello *et al.*, 2014).

Reliability of infrastructure also has to do with its vulnerability, which connotes susceptibility to incidents such as climate change (sea level rise/flooding, storm events and so on) and can result in considerable reductions in road network serviceability (Friedrich and Timol, 2011). The ability of transportation networks to withstand other vulnerability-related incidents including natural disasters such as earthquakes, and anthropogenic events such as terrorist attacks, which could have a resultant effect on traveler behaviour, travel time delays and trip costs, also indicate reliability (De Oliveira *et al.*, 2014; Faturechi and Miller-Hooks, 2015).

Institutional factors

The institutional arrangements obtainable on an infrastructure project are critical indicators of sustainability. Institutions are defined as formal or informal rules of a society or of organisations that modify (facilitate or constrain) human interactions and functions (Brouwer and Ittersum, 2010:41) Institutional aspects cover various legal, governance, administrative, institutional, management structures (government agencies, private companies); as well as other non-technical aspects and arrangements, which serve as basis for decision-making (World Bank, 2013:15; Quium, 2014:45). It also includes enforcement and compliance with regulations; arrangements and structures for financial resource allocation, management and operations; project decision makers or champions; service quality/performance; technical capacity and incentive frameworks (Salman *et al.*, 2007; World Bank, 2013; 2014b; Upadhyaya *et al.*, 2014; Cottrill and Derrible, 2015; Barnes-Dabban *et al.*, 2017).

In relation to the institutional framework governing the operations on the project, the quality of service provided by the institutions in place reflect the level of sustainability. Service quality has to do with the efficiency and effectiveness of works and provision of services and how well the system and services are doing financially and technically (Haas *et al.*, 2009; Ramani *et al.*, 2009; Dhingra, 2011:28). It reflects costs and benefits ratio, maintenance costs, expenditure and learning possibilities.

The concerned parties in an institutional arrangement need to be clear on specification of deliverables, reference design or rigid tender specifications, minimum standards for condition of infrastructure, roles and responsibilities of different parties involved, performance targets, penalties for non-compliance, and procedures for amendments, dispute resolution or termination, renegotiations, if any (Liyanage *et al.*, 2015). The division of responsibilities of the private and public partners should be governed in an elaborate and precise performance contract stipulating the responsibilities of the parties in operation and maintenance of the road infrastructure assets as well as procurement of transport, vehicles/equipment; (Levitt and Eriksson, 2016:7). This will also assist in establishing boundaries of control by both parties and providing monitoring and efficient transport infrastructure management while in operation.

Further, the capacity of the parties designated to operate and maintain the infrastructure is essential. Having a competent and experience concessionaire who is capable of applying knowledge and expertise in sustaining and maintaining infrastructure is a vital sustainability measure (Carter, 2015). The efficacy of institutional frameworks, coupled with the favorable regulations and governance, helps in transparency and increase in confidence to invest as well as delivery of sustainable infrastructure projects (Quium, 2014:49).

In summary, the following factors were identified from the literature discussed in this section, to be indicative of sustainable transportation infrastructure (Figure 2.3):

- Financial and economic factors (affordability, costs, revenue/cash flow) (Jeon *et al.*, 2010; Litman, 2016; Pinard *et al.*, 2016);
- Social factors (accessibility, public acceptability/complaints, demand, willingness to pay set fees, user satisfaction, safety, comfort and convenience (Dhingra, 2011; Pavlina, 2015; Mišic and Radujković, 2015; Osei-Kyei and Chan, 2016);
- Environmental factors (preservation of the environment and compliance with environmental regulations (Ramani *et al.*, 2009; Karlaftis and Kepaptsoglou, 2012; National Geographic, 2016);
- Physical infrastructure factors (condition and capacity of infrastructure) (Karlaftis and Kepaptsoglou, 2012; Ramani *et al.*, 2009; Alasad *et al.*, 2012; 2013);
- Institutional factors (coordination, service quality, structures for management and operations, service quality, responsibilities and capacity of partners) (Quium, 2014; Upadhyaya *et al.*, 2014; Cottrill and Derrible, 2015; Barnes-Dabban *et al.* 2017).

The above factors were theorised, from the above literature review, to measure and or assure sustainability of transportation infrastructure projects.

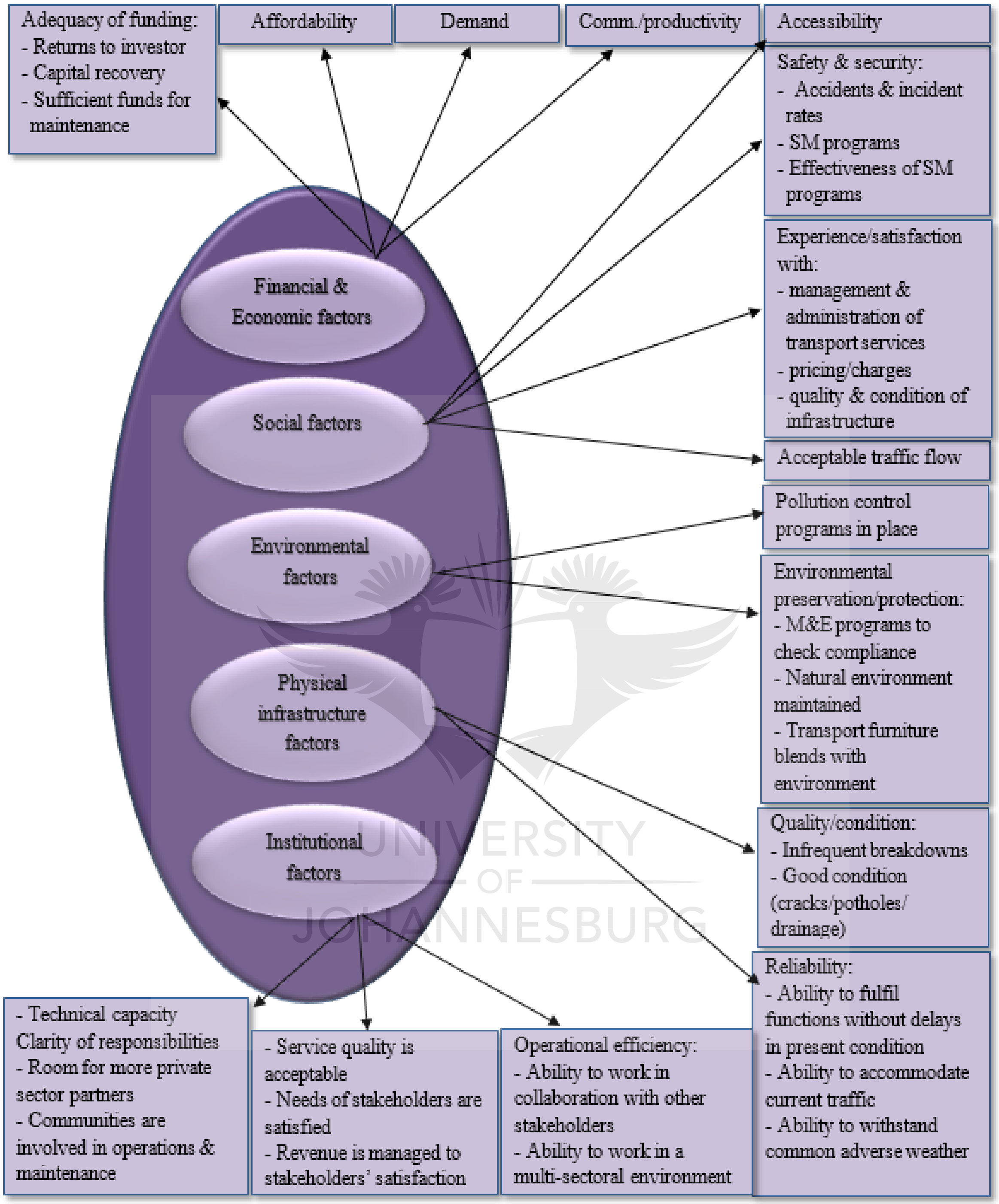


Figure 2.3: Five-factor sustainability framework

2.3 CHAPTER SUMMARY

The current chapter discussed the concept of sustainability in infrastructure projects. Sustainability assessment methods and tools as well as indicators have been reviewed. Literature informed that transport infrastructure sustainability should balance the traditional three-dimensional aspects (economic, social and environmental). In addition, it is critical that governance and institutional factors, which ensure that the three named aspects are integrated, are sustained. Further, the physical attribute of infrastructure such as quality or condition was found to be an important sustainability indicator. Addressing sustainability requires consideration of these discussed spheres at the planning stage, during the feasibility studies. The feasibility stage offers the best time in a project's life cycle to assure sustainability. The next chapter will therefore discuss, in detail, the feasibility studies conducted in transportation projects.

CHAPTER THREE

TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDIES

3.1 INTRODUCTION

Transport infrastructure development process starts with assessing the need in a particular area and evaluating the costs, benefits and impacts of a proposed project on the people as well as the environment. Feasibility studies are carried out to predict these costs, benefits and impacts. For investors, the quality and comprehensiveness of feasibility studies is critical as incorrect decisions can have direct financial, economic and social consequences ultimately affecting the sustainability of the projects. An investor, who has alternative projects to invest in and needs to decide on the most viable option in the long run relies on the feasibility study undertaken.

The current chapter will present literature on the importance and quality of feasibility studies. In addition, a review of factors, which influence the quality of feasibility studies, as well as what constitutes a comprehensive feasibility study, is presented.

3.2 FEASIBILITY STUDIES

The feasibility study was earlier on defined as evaluating the suitability of a single or multiple proposed system solution(s) to an identified business problem according to a set of criteria, called criteria factors (Palvia and Palvia, 1998:212). With the exception of inclusion of more criteria factors, the definition of feasibility studies has not changed, as evinced in recent literature. The feasibility study is defined as an instrument, which may offer a technical, economic and financial base in the taking of the decision to finance an investment project (Ioan, 2010:127). It is a process, which follows the conceptual ideation of a project and entails a detailed assessment of the viability of a project from different points of view including technical, financial, social and environment aspects as well as legal structuring to ensure value for money (Hyari and Kandil, 2009).

Feasibility study is a multi-dimensional set of actions, which aims to analyse and evaluate a project to determine if its construction is feasible, among other economically preferable, financially viable, socially and environmentally appropriate alternatives (Tsimplokoukoutt *et al.*, 2012:91). A feasibility study is a comprehensive assessment or analysis of a given project in consideration of the four Ps (people, power, processes and plan) in order to determine whether it should go ahead, be reconsidered or else totally abandoned (Melsy, 2016).

Feasibility studies involve identifying potential benefits (profit, business development, resource utilization and job opportunities) and risks (land depreciation, unsatisfied users, technical risks, payback period, break-even period, interest rates, and so on), testing the sustainability of structures and strategies (through indicators) and making statements about the future, given the uncertainties identified (Waghmare and Pimplikar, 2012:3167). Proposed projects are analysed and evaluated to discover positions or situations, which may jeopardise the projects in the long run (Melsy, 2016). Thus, feasibility studies of a given infrastructure project are assessments made available to decision-makers, investors and project planners at the time of decision to build the project (Flyvbjerg, 2005).

3.2.1 Nature of feasibility studies

Feasibility study is multi-phased, multi-dimensional and iterative evaluation and ranking of alternatives with regard to development approaches, risks, costs and benefits (Mackenzie and Cusworth, 2007). It comprises numerous elements (Ioan, 2010:127). It is an analysis of a complex nature, undertaken to:

- demonstrate the technical and economic viability of a project;
- develop a project configuration and investment case and define the scope, cost and quality;
- establish the risk profile, and associated uncertainties and develop mitigation strategies to reduce likelihood of significant changes in the project later on;
- plan the implementation phase to produce a baseline for management and control as well as management plan for operation phase;
- facilitate procurement of sufficient funds; and
- develop a clear recommendation to proceed or otherwise
  (Mackenzie and Cusworth, 2007).

Feasibility study entails establishing the requirements, boundaries and expected outcomes including who is responsible, project brief and proposal to be analysed, who should be involved, level of detail, report back date and budget for the study (Burger, 2013:93). In the implementation stage of feasibility studies, decisions have to be made with regard to the design, construction, operation and maintenance of proposed projects in a multi-phased and iterative process. The feasibility study process basically includes collection of background information, evaluation of proposed options, selection of options, as well as conclusions and recommendations (Subash *et al.*, 2013:74). Alternatives are narrowed down and selected based on the evaluation of different phases including:

- the scoping phase, which defines the potential of the projects, eliminates options which are unlikely to be optimal, and seeks to answer if there is sufficient opportunity or justify the investment or pursue the opportunity;
- the prefeasibility stage, which is used to analyse and select preferred alternatives defined by the scoping study and to provide a case for whether to commit to the project; and
- the full or definitive study, which refines the optimal operating scenarios defined in the prefeasibility study and examines conditions which could hamper the projects' viability (Mackenzie and Cusworth, 2007).

The defining point of this multi-dimensional and multi-staged set of evaluations or actions (Figure 3.1) leads decision-makers to decide if a proposed option or project should be implemented or terminated (Hyari and Kandil, 2009:72; Tsimplokoukout *et al.*, 2012:91; Subash *et al.*, 2013:73).

Transport investment decisions are basically made based on feasibility study outcomes that support cases for selection and implementation of the projects. These include the:

- strategic case, which shows a robust case for change that fits with wider public policy objectives;
- economic case, which demonstrates the value for money;
- commercial case, which demonstrates how commercially viable the project will be in terms of business opportunities to the locality;
- financial case, which reveals how financially affordable the intended project will be in terms of costs/expenditure and revenue; and

- management case, which demonstrates if the project is achievable in the long run (Department for Transport, UK, 2015).

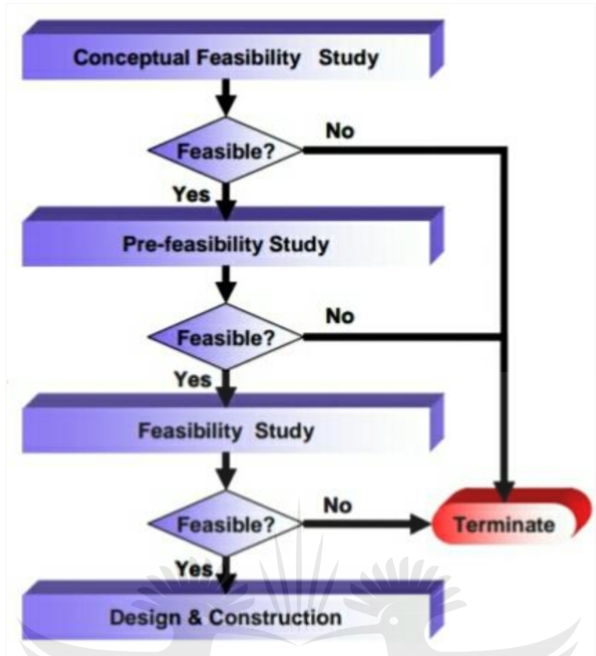


Figure 3.1: Multi-stage feasibility study (Source: Hyari and Kandil, 2009:72)

The feasibility aspects above tend to suggest that there are different aspects of an infrastructure project's performance considered in feasibility studies. A typical feasibility study follows the process depicted in Figure 3.2 and entails:

- technical and design considerations (operability, constructability, approach, route characteristics, expansion capacity, augmentation possibility);
- environmental factors (impact of failure during construction and operations);
- socio-economic factors (right of way, disruption of lifestyle, pollution, burden on existing infrastructure and safety); and
- financial analysis (costs and revenue) (Huh *et al.*, 2012; Tsimplokoukout *et al.*, 2012).

Other considerations include establishing the need for the project, service delivery requirements and alternatives, physical factors (site influences) as well as procurement methods, management capabilities, affordability, demand and acceptability issues, financial estimates (bankability) and implementation viability (Mackenzie and Cusworth, 2007; Valentin *et al.*, 2012; Martin and Jo, 2014; Erlich, 2015; Kraul, 2015; Nematollahi and Kim, 2017).

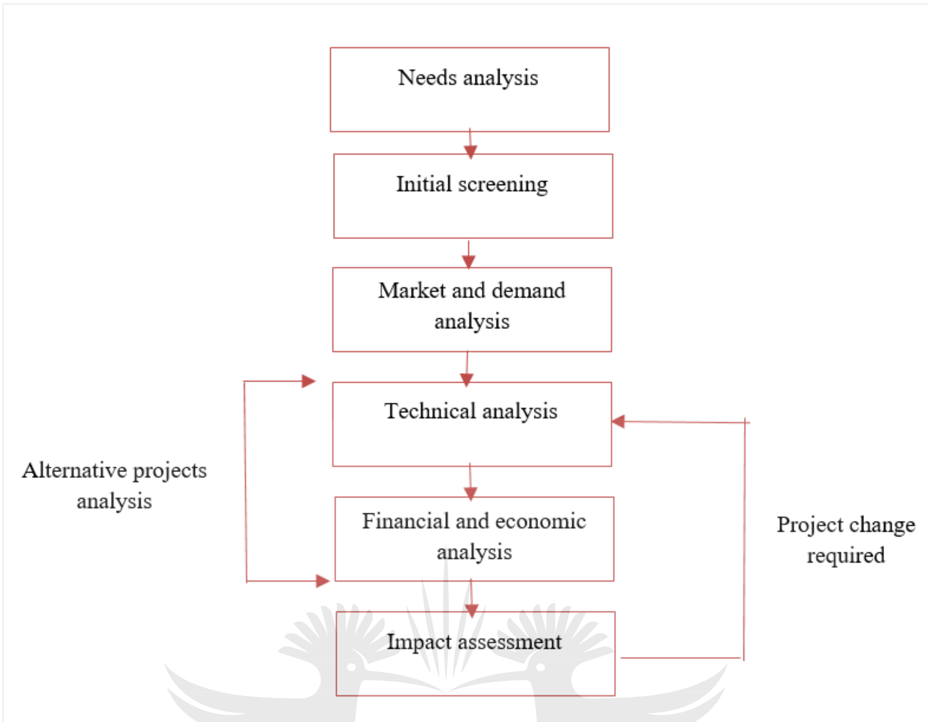


Figure 3.2: A typical project feasibility study process (Source: Dey, 2001:237)

The feasibility study phases can be expanded to clearly delineate steps in the procedure (Mackenzie and Cusworth, 2007:3; Hyari and Kandil, 2009:68). These steps include:

i. Identifying alternatives for the project under consideration
ii. Collecting all possible data about practical alternatives
iii. Making necessary forecasts and projections of base year data for the project useful life
iv. Determining evaluation methods for appraising project alternatives
v. Evaluating alternatives based on the selected evaluation methods
vi. Recommending action based on the findings of the study

(Wey and Wu, 2007; Mackenzie and Cusworth, 2007; Hyari and Kandil, 2009).

In addition, selection of a project among alternative projects is useful in order to maximise the net benefit to the investor (Wey and Wu, 2007:986). To select a project among various alternatives, with a lot of factors to consider such as need, location, interests, goals and available resources before an investment decision is made, requires time (Wey and Wu, 2007). Adequate time to conduct the study without pressure to skip any of the stages/steps in the process is therefore essential during feasibility studies (Hyari and Kandil, 2009).

A feasibility study, therefore, essentially provides evidence to justify a project's bankability, financial viability, political will, social acceptance, technical, environmental and economic feasibility (Venter *et al.*, 2001). Hence, a variety of factors should be considered in order to adequately weigh investment options that are viable and accrue optimum returns in the long run.

3.2.2 Importance of feasibility studies in infrastructure planning

The success of a project is determined by the assumptions that are set during the feasibility process (Tsimplokoukout *et al.*, 2012). Feasibility studies critically evaluate existing situations to identify suitable solutions for a problem or need (Figure 3.3) (Hyari and Kandil, 2009; Department of Water Affairs and Forestry (DOWAF), 2002). One of the main weaknesses in transport infrastructure sector is the lack of planning at the onset of projects, which has a ripple effect on the projects at the operational stage (Kehagia, 2009). Often, the main cause of project failure is an inadequate understanding of the project viz-a-viz risks (deviation from expected or wanted results), rewards and a plethora of uncertainties which infrastructure developments are fraught with, with regard to costs, benefits, schedule, demand and risk estimation and control (Hampton, 2009; Kim, 2010; Waghmare and Pimplikar, 2012:3168; Salet *et al.*, 2013).

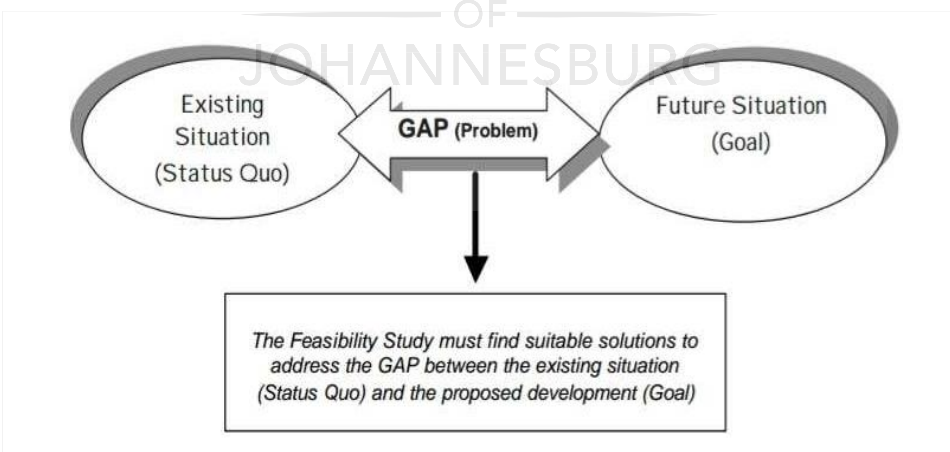


Figure 3.3: Import of feasibility studies (Source: DOWAF, 2002:2)

Highly inaccurate forecasts combined with large variations translate into large financial and economic risks, which are unfortunately downplayed by planners and decision-makers, to the detriment of social and economic welfare (Flyvbjerg *et al.*, 2008). These uncertainties and risks, which make it difficult for decision-making regarding investment in transport infrastructure, if not accurately predicted in the planning of projects, often result in undesirable financial, social and economic consequences because inappropriate decisions are made based on erroneous feasibility evaluation outcomes (Mentis, 2015). For instance, a new $2.6 million educational infrastructure development in Uganda somewhat "failed" as it received only 17 students over eight months (Global Construction Review (GCR, 2016). This was because system-related information such as demand for its services was not clearly analysed or shared with the public (users of the facility).

In another example, Bangkok's US$2 billion Skytrain, whose passenger estimate was 2.5 times higher than the actual traffic, resulted in inadequate design specifications, long platforms, large terminals and train sheds were built and the project company landed in financial trouble (Flyvberg, 2005). In a similar situation, more than five years after opening to the public, the Channel tunnel's Eurostar train passengers numbered only 45% of that forecasted for the opening year and rail freight was 40% of that forecasted, resulting in several near bankruptcies (Flyvberg, ibid.).

Another notable instance of traffic demand underestimation is South Africa's first high-speed metropolitan transport network – Gautrain – which was developed at a cost of nearly R25 billion. The project was needed in order to alleviate congestion in Africa's premier business and industrial region (van der Westhuizen, 2007:334). In a recent statement by the Gautrain management, it was reported that Gautrain reached its predicted number of users four years earlier than anticipated as it was currently commuting the number of passengers it had planned to achieve in 2020, which is about 60,000 passengers per day (Nicolaides, 2016). In addition to the apparent congestion at the stations resulting from this, the unexpected high numbers have meant that there will be more expenses which will be incurred in order to provide forty-eight additional carriages to cater for the current number of people using the trains daily. This also means that funds, which could otherwise have been utilised for other necessary infrastructure development projects, will be channeled into the existing transport project. This becomes a case of inefficient resource allocation, as was argued in Welde and Odeck (2011:81). These views were echoed in another study where demand was overestimated on road and rail projects by 11.12% and 18.48% in the United Kingdom (Nicolaisen *et al.*, 2012).

Expounding on the consequences of inaccurate estimation, Flyvbjerg *et al.* (2005) iterated that under-estimation errors lead to multi-millions in expenses as it is much more expensive to add capacity to the existing fully used roads than it was to build the capacity up front. The Gautrain project in South Africa, for instance, which was under-estimated in terms of demand required additional carriages and new routes to cater for the demand (Nicolaides, 2016). This plan would undoubtedly require a tendering process, obtaining permissions, and construction activities, which have negative impacts on nearby populace during development as well as extra costs which could have been channeled into other development plans. An initial underestimate will show poor revenue streams and may make the project unworthy of attention and might subsequently be inflated in the actual feasibility studies in order to avert this (Godard and Fatonzoun, 2002). If actual demand exceeds forecast values in subsequent years, it is a business opportunity lost to the private sector and a social loss.

In addition, doing nothing or finding alternative methods of mitigating traffic problems (which is usually the main reason for investing in and providing reliable transport infrastructure) by the state may be expensive and impose economic burdens on the community. With the Kazungula bridge bordering Zambia and Botswana, crossing the Zambezi River, forecasts of traffic patterns were predicted that by 2015, traffic crossing the Zambezi River will grow between 1.75 times (in the case of low growth rate scenario) and 2.56 times (for high growth rate scenario) (Infrastructure Consortium for Africa (ICA), 2007). However, the actual traffic had exceeded this and warranted expansion of the bridge to accommodate road and rail traffic into Zambia. Such incidences of traffic underestimation purport that capacity relief on congested links, in the case of road projects, could turn out to be lower than planned and this could result in a significant distortion of the social viability of such projects and result in non-viable projects being implemented. Therefore, inaccuracy in forecasts influences project outcomes and the uncertainties that may influence the forecasts warrant attention.

Feasibility studies are therefore critical in reducing uncertainties in order to make better decisions, which otherwise, can lead to disastrous consequences (Hassan *et al.*, 2013: 2). Moreover, the importance of the feasibility study is linked to the significant decrease of the risks taken by the one who undertakes them, when attempting to capitalise on identified economic opportunities (Ioan, 2010:128). A poorly defined project, at the feasibility stage, will not deliver the same outcome as a well-defined project no matter how well it is executed and operated (Mackenzie and Cusworth, 2007:3).

However, feasibility studies appear to be uncertain, highly inaccurate and often display a concerning degree of bias (Flyvbjerg, 2007a; Nicolaisen *et al.*, 2012; Salling, 2013). This results in scarce financial and natural resources being wasted since investment decisions and projects, which are usually capital-intensive (huge amounts of funds injected), are made and built with misleading information regarding their potential capacity to succeed (financially and otherwise) while in operation and to serve generations of users (Waghmare and Pimplikar, 2012:3168; Roxas *et al.*, 2015:82).

Consequently, serious problems, which could be averted to a great extent in the planning of such risky endeavors, arise, if they are not given adequate consideration. Proficient planning and proper evaluation are needed to identify potential impacts, costs and benefits accruable to a project. Infrastructure project owners, decision makers, and investors decide to proceed with a given project (new and/or otherwise) based on the results of the feasibility study carried out at the planning stage to identify different elements/aspects of the project that pose risks and may affect the expected revenue/returns from the project. Therefore, based on the outcome of feasibility study, projects that deserve to be built are built and those that do not are abandoned.

3.3 IMPROVING THE QUALITY OF FEASIBILITY STUDIES

The objective of a feasibility study is to find a model, which balances simplicity, timeliness, and breadth of generality or adequacy (Kim, 2007). Feasibility studies compare predicted conditions (costs and benefits) with current ex-ante based estimates for a subject infrastructure project (Hyari and Kandil, 2009:68; Salling, 2013:474). Although there is no agreed standard to measure the quality of feasibility studies, feasibility studies should ideally reflect the impact of the discrepancy between the estimated and actual conditions (Hassan *et al.*, 2013:4). It is difficult to measure adequacy or ensure absolute accuracy of feasibility studies, but a good feasibility should be comprehensive and consider the full range of issues likely to affect the intended objectives of the project and cost alternatives to achieve identified benefits (Hyari and Kandil, 2009; Salling, 2013).

The Oxford Learner's Dictionary (online) defines the term 'comprehensive' as "including all, or almost all, the items, details, facts, and information that may be concerned" (Oxford Learner's Dictionary, 2019: online). The term "comprehensive" refers to 'a range of factors about the way things ought to be, and which form a conception of the good and inform judgements' (Voice, 2014). It is 'the need for a single tool to perform all required actions, at all stages, covering all disciplines' (Johnson, 2013). Therefore, a comprehensive feasibility study is crucial since it comprises a detailed plan and prediction of outcomes of a project, undertaken through structured process stages, based on an array of related or unrelated parameters, all of which affect the project at one stage or another (Macdonald, 2007; Jayasinghe and Baillie, 2017). It is a structured way of assessing the technical, financial, social, and environmental viability or practicality of a project, which is used to make decisions about whether a project should be implemented (Jayasinghe and Baillie, 2017). Such parameters may include environmental, technical, project financial (including costs and revenues), physical plans and details for a project, which can be changed, discarded or replaced to selected the most satisfactory combination of alternatives (Macdonald, 2007).

In addition, high quality feasibility studies should critically assess better ways to achieve the objectives, better uses for the resources available and clearly explain the relevant information used to narrow and select the most feasible alternative among the range of alternatives considered (Macdonald, 2007). Evaluation of alternative project configurations (maximum benefits and minimal costs) and making decisions based on the evidence, of what the optimum configuration will be, ensures adequacy of the feasibility study (Mackenzie and Cusworth, 2007:2). Feasibility studies should essentially be holistic in nature, covering social, economic and environmental impacts of projects, coherent and consistent with policies (World Bank, 2005:2). In addition, for feasibility studies to be considered good quality and comprehensive, all possible criteria factors must be incorporated in the assessment, using appropriate methods, and data as well as involving the right people and following the right procedure.

3.3.1 Criteria factors incorporated

Feasibility studies consider a plethora of factors. Grant *et al.* (2012) and Rudžianskaitė-Kvaraciejienė *et al.* (2015) indicated that if certain variables such as safety or quality of life factors or impacts or design parameters, are overlooked or underestimated in feasibility studies, this could result in erroneous estimates, which could in turn lead to financial or social costs to the investors and community and poor performance of the projects while in operation. Infrastructure projects could fail due to poor feasibility studies as a result of inadequate inclusion of uncertainties in model forecast. Non-inclusion of all potential critical factors affects the accuracy of forecasts and subsequently, the outcome of projects in terms of cost, demand shortfalls and associated benefits from transport infrastructure development (Parthasarathi and Levinson, 2009:5; Glaister *et al.*, 2010:11; Alasad *et al.*, 2012:328; Mišic and Radujković, 2015:72). Factors which influence project sustainability emanate from uncertainties regarding the differences between the forecasted and actual costs and benefits (revenue and satisfaction to the stakeholders) (Parthasarathi and Levinson, 2010; Glaister *et al.*, 2010; Salling and Leleur, 2012).

The criteria factors are discussed hereunder with regard to the identified broad feasibility study factor categories presented in Table 3.1. These include technical/physical, economic, financial, environmental, social, legal, and management factors.

3.3.1.1 Technical/physical factors

Technical feasibility assessment is a prerequisite to demonstrating the viability of a project (Mackenzie and Cusworth, 2007). Technical feasibility entails evaluations of structural feasibility and topographical configuration given geographical scope and unique location characteristics of individual transport projects (Tsimplokoukout *et al.*, 2012:92). In the planning of new transportation infrastructure, feasibility studies evaluate technical alternatives for construction in order to aid decision-making step regarding the best and most cost-effective routes (Okoro et al., 2016). Furthermore, any planned improvements to surrounding transport network and systems are considered in technical feasibility studies. Aspects such as design speed and geometric attributes including alignments, curves, elevation, and number of lanes are important considerations especially with regard to safety (Neeraj and Kazal, 2015; Vayalamkuzhi and Amirthalingam, 2016).

In addition, the design stage is a critical consideration in technical and physical feasibility studies. This is especially important in the face of global climate change. The concern here is the performance and reliability of road transport infrastructure in relation to the effects of climate change on the structure and materials (Friedrich and Timol, 2011; Twerefou *et al.*, 2015). Thus, transport infrastructure must be able to function and perform effectively throughout its expected life cycle and it is therefore critical to take cognisance of the potential effects of natural weather occurrences on materials (Friedrich and Timol, 2011; Faturechi and Miller-Hooks, 2015).

3.3.1.2 Financial and economic feasibility factors

Economic feasibility study of a project is an estimate of the potential profitability of the project, or benefits from a certain project relative to its cost (the main index regarding the value of investment) (Tsimplokoukout *et al.*, 2012:93). In this sense, benefits (including wider economic impacts as well as localised individual and community benefits) are weighed against costs (Ioan, 2010:128). Financial and economic studies define the investment costs which include the fixed costs (land, building, equipment, construction, and so on), financial schedule, resources, budgets, revenue or benefits (Abou-Zeid *et al.*, 2007:24).

Other costs include expenditure to maintain infrastructure facilities, capacity expansion, operations, as well as cost recovery options, internal (through user fees) or external (via fuel taxes, vehicle registration fees, and so on) sources are evaluated in financial and economic feasibility studies. These costs are critical since the sources of revenue to recoup capital and assure sustainable cash flow (returns) from the project have to be established and assured before the project commences (Glaister *et al.*, 2010; Mišic and Radujković, 2015). An investor or concessionaire needs to know that there will be assurance of cash flow with an acceptable and affordable tariff while at the same time striving to finance obligations and still maintain a profitable rate of return (World Bank, 2016). Further, financial and economic analysis therefore includes demand and supply analysis, finance risk assessment, market forecast and competition as well as return on financial channels and investment plan/strategy assessments (procurement and management) (Siemiatycki, 2010:31; Tsimplokoukout *et al.*, 2012).

Decisions have to be made regarding sources of funding or investment plan (traditional, consisting of internal and external sources as shown in Figure 3.4, or innovative comprising public-private partnerships (PPP) mechanisms as shown in Figure 3.5, depending on the level of private sector involvement) (Siemiatycki, 2010:31; Liyanage *et al.*, 2015). Traditional sources of funding, including taxes, user charges and domestic borrowing, are not always sufficient since transport infrastructure can seldom be supplied at an acceptable profit. In addition, there is no efficient way to collect income from users (by private investors, where involved (Abelson, 2003). Hence, participation of the private sector in different forms is desirable to make resources readily available, encourage the delivery of higher quality and citizen-friendly services, as well as the most effective and efficient use of the resources (Pârvu and Voicu-Olteanu, 2009:190).

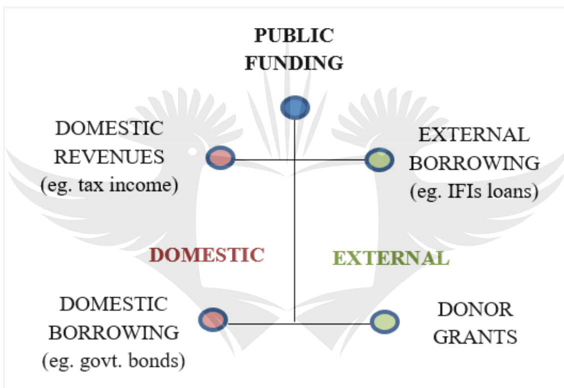


Figure 3.4: Traditional sources of funding (Source: FTI, 2013:62)

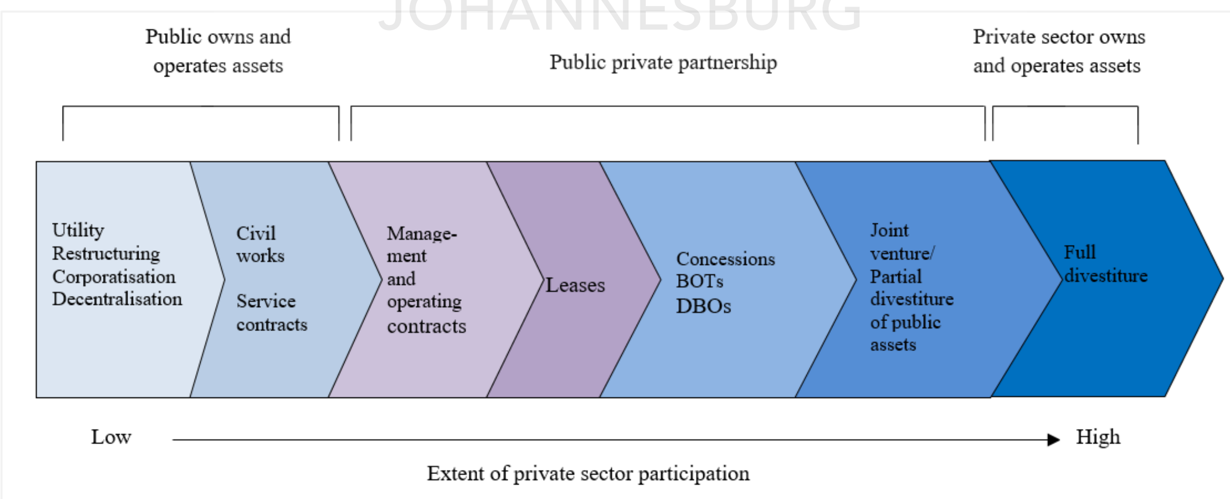


Figure 3.5: Forms of PPP depending on the private sector involvement (Source: World Bank, 2016)

Further, the economic cost of a proposed project is a critical consideration. These are significant because transportation infrastructure projects have externalities, which impact negatively on people. Therefore, the opportunity costs of selecting a project alternative, especially in an area of ecological value, should be weighed (Wiener, 2014; Standish and van Zyl, 2015).

Therefore, the result of the financial and economic analyses, for the time span taken into account, must illustrate the availability of financial resources in the covering of the functional necessities of the given system, with a purpose to ensure the development of the project and the satisfaction of all financial obligations (Ioan, 2010:128). Moreover, the value for money in spending tight public finances, and deliverability of the infrastructure project within budget are key considerations (Prokopowicz, 2014; Halil *et al.*, 2016).

3.3.1.3 Environmental feasibility factors

Transportation infrastructure developments have an impact on the environment. This can be through environmental pollution, which negatively affects the quality of life (Tsimplokoukout *et al.*, 2012; Surbeck and Hilger, 2014:2078). Environmental feasibility studies therefore entail assessments of impacts to ensure that the construction and operational processes, including envisaged operational activities are environmentally and legally complianhow to t (Mwemezi and Luvara, 2017). Factors such as legal compliance issues, impacts on the environment and nearby populace as well as mitigation measures for possible externalities are therefore key considerations (Erlich, 2015).

3.3.1.4 Social feasibility factors

Social feasibility studies include an assessment of the influence of proposed projects on the local social development, development of new settlement, businesses, job creation, cultural heritage conservation, accessibility, affordability, comfort and convenience, quality of alternative modes of travel, travel time, network connectivity, land use proximity and safety standards (Tsimplokoukoutt *et al.*, 2012; Jacobson *et al.*, 2013). Social feasibility studies also assess the value attributable to alternative options for travel or access to opportunities (Graham and van Niekerk, 2014). This value, termed “option value”, is the ability to choose a particular mode of transport or route to get to one’s destination, community impact as well as social inclusiveness.

Further, the value of provision of an alternative option is weighed against externalities in environmental and social feasibility studies. Value attributed or ascribed to the environment, especially based on locality values, for instance using “benefits transfer” significance, is weighed against the future value of intended projects (Standish and van Zyl, 2007:151). It is critical to weigh the benefit of providing a project versus the cost of losing environmental value over a long term (in the form of recreational value, for instance) (Standish and van Zyl, 2007).

3.3.1.5 Legal feasibility factors

Legal factors are considered in transportation infrastructure feasibility studies. These have to do with policy, legislative and administrative frameworks/ instruments and requirements which a proposed project must comply with (Beria, 2007). Proposed projects are evaluated on the basis of their level of compliance with the law. The building of infrastructure takes cognizance of certain factors such as minimum traffic, environmental impact, safety regulations and evaluation of alternatives as required by law (Beria, ibid.). Any legal issues forbidding the project and modifications required to proceed are considered in feasibility studies (Aboud-Zeid *et al.*, 2007:24). These also include land acquisition and compensation matters (Salman *et al.*, 2007).

3.3.1.6 Strategic and management feasibility factors

Strategic and management factors are considered in the feasibility studies for transport infrastructure. This entails an assessment of and decision-taking on facets of the project as regards strengthening of the investment environment, including involvement of stakeholders, sufficient resources, a conducive corporate environment, appropriate management, effective planning, a fair competitive environment, integration of units, good working relationships, a planning process responsive to changes and challenges, a safe and ethical social and political climate and favourable corporate strategic environment (or good corporate governance) (Ugboro *et al.*, 2010; Melsy, 2017).

Other strategic factors include the level of government support, commitment, and leadership, as well as financial regulations, which influence the financial performance of projects (Glaister *et al.*, 2010; Zuofa and Ochieng, 2014; Carter, 2015; Mišic and Radujković, 2015; Osei-Kyei and Chan, 2016). Further, strong support, strategic, appropriate and predictable guidance, uncompromised authority and reasonable transparency (even with low level of authority), ability to command the powers to deliver the project, less fragmented transport governance influence the performance of projects (Devkar *et al.*, 2009; Glaister *et al.*, 2010; Mišic and Radujković, 2015; Osei-Kyei and Chan, 2016). Competent concessionaires, well managed contracts and interaction among partners also influence the performance of projects (Byaruhanga and Basheka, 2017:33).

3.3.2 Feasibility assessment methods employed

Feasibility methods used for a given project influences the estimation outcome (Flyberg *et al.*, 2006; Jeerangsuwan *et al.*, 2014). Etemadnia and Abdelghany (2011) concurred that forecasting methods/systems, for instance, as used for road traffic forecasting, could influence the performance outcome in terms of congestion. It was further indicated that forecasting methods that have been used in recent times, especially in traffic estimates, have been unable to meet the real-time processing needs, especially for large-size networks, and that there is a high dependency on historical information which could be misleading considering the highly dynamic and stochastic nature of congested urban networks (Etemadnia and Abdelghany, ibid.). Furthermore, Al-Masaeid and Al-Omoush (2014:329), who investigated traffic forecasting methods (including Bayesian, regression and trend analysis) in Jordan supported that different methods of estimating result in different margins of error.

According to Kim (2007) and Hassan *et al.* (2013), forecasting methods can be either subjective or objective in nature depending on availability of data and the period of investigation (distance into the future for which a forecast is required). Subjective methods are based on judgements and opinions and usually used where there is limited or no historical quantitative data available and for more distant time horizons. Examples include the Delphi method, benchmarking, and so on. On the other hand, objective methods are statistical in nature and they are used whereby there is historical data and for not too distant time horizons. Objective forecasting methods can be divided into extrapolative and regression methods. Extrapolative methods, also known as autoregressive or exponential smoothing models, consider that the forecast is a function of time and past values of the variable of interest and not of other variables. Some of these methods include:

- *Capacity analysis*: In capacity analysis, projects' potential ability to continue performing, technically and economically, in the face of increasing demand (traffic) (Ghosh et al, 2013: 441) as well as natural disasters (Friedrich and Timol, 2011; Faturechi and Miller-Hooks, 2015), is weighed against costs;

- *Delphi method:* The Delphi method, which asks for a prediction to a panel of experts for several rounds, expecting that a prediction converges towards a "correct value";
- *Reference class forecasting (RCF) and Benchmarking*: The RCF and benchmarking approaches adopt the outside view, objectively evaluating past performance data or opinions of stakeholders who do not have a vested interest in getting the project up and running and mitigates strategic misrepresentation (deliberate misrepresentation of project costs and risks for political, economic, and/or other gains), in addition to optimism bias, which is inherent in CBA analyses (Liu *et al.*, 2010; Flyvberg *et al.*, 2016). They depend on previous performance of similar projects to forecast the future performance of projects. The benchmarking method also entails comparing the forecasts of a model with those obtained by best-class models, as was done in Wegman and Oppe (2010) and Chen *et al.* (2016) who opined that adoption of benchmarking results helps to ensure that best alternatives are selected;
- *Regression:* This estimates the effects of causal variables and includes econometric models, among other things. In Al-Masaeid and Al-Omoush (2014:321), multivariate aggregate regression analysis was conducted to estimate traffic volume as a function of socio-economic and demographic variables;
- *Trend analysis:* Al-Masaeid and Al-Omoush, (2014:322) also used disaggregate trend analysis to examine the traffic volume based on historical data but indicated that huge margins of error existed with the use of this approach in predicting future traffic volumes;
- *Bayesian analysis:* The Bayesian approach uses prior knowledge or historical data (though restricted by changes in population, demography and employment), to form a refined distribution called the posterior distribution, which then forms the basis for predicting the mean growth rate (Al-Masaeid and Al-Omoush, (2014:322).
- *Cost-benefit analysis (CBA):* The CBA is an evaluation technique that incrementally compares the societal benefits and costs, measured in monetary terms, of proposed projects and policies, to find the greatest net benefits (McNally *et al.*, 2017). According to Cervero (2011) and Jones *et al.* (2014), the CBA compares the relative merits of two or more transport alternatives, incorporating different scales including environmental and social impacts, albeit in economic terms, monetising the variables based on a socially accepted valuation system. However, in their study of road projects forecasting accuracy in Norway, Welde and Odeck

(2011:81) opined that the CBA has a major shortcoming in the sense that it relies heavily on the accuracy of the estimates influenced by the monetary values ascribed to the variables;

- *Strengths, weaknesses, opportunities and threats (SWOT) analysis*: Warren *et al.* (2015:138) and Blanco and Moudon (2017:4692) opined that an analysis of SWOT when planning an infrastructure project assists in evaluating alternative investments, developing strategies to actively confront the threats with strengths, avoiding exposures where the weaknesses meet threats, maximising potential where strengths meet opportunities and improving to meet potential where weaknesses meet opportunities; and
- *Environmental impact assessments (EIA*): The EIA can forecast the environmental impacts, both negative and positive, from proposed development projects because it can be used to establish the appropriate mitigation measures for preventing and mitigating negative impacts (Naser, 2012:235). However, it considers only basic assertions such as improvement in safety, reduction in costs, and improvement in accessibility and economic developments; no impacts are predicted (Douthwaite, 2007:9).

The above methods can either be used in isolation or combined, due to their inherent inconsistencies, and relative advantages and disadvantages (Abou-Zeid *et al.*, 2007).

3.3.3 Data used

The quality of feasibility studies depends on the availability and nature of data used in the assessment of the planned project. Data used in feasibility studies may be obtained from traffic counts and forecasts, existing reports, infrastructure master plans and household survey data (which influences travel demand and charges) (Etemadnia and Abdelghany, 2011; Katahira and Engineers, 2013).

However, sometimes, data availability is a concern in feasibility studies. Project managers may not easily disclose information regarding traffic counts or comparable projects. Data used may be subjective in nature, where obtaining data from the custodians prove to be an uphill and time-consuming process. In such cases, where no data exists for statistical techniques, expert judgemental forecasting can provide insights (Kavanagh and Williams, 2017). However, judgemental forecasts are inherently biased because they are neither transparent nor easily replicated.

Other times, the data may be tampered with or adjusted to make the project look good in the public eye (Flyvberg *et al.*, 2006). The people involved in the feasibility studies then use erroneous or outdated data, which influence the outcome of the feasibility studies. Additionally, in some cases, reference data from the first year of operation of a similar project may be used in comparison. However, the data may not yield reliable results because the project had not stabilised in the first year (Flyvberg *et al.*, 2006). This gives rise to misrepresentation of data and thus inaccurate prediction of performance.

Furthermore, feasibility study outcomes could become obsolete if there are huge time lapses between construction life cycle phases, especially in the case of mega projects, which usually take a number of years to implement (Kennedy, 2015). For instance, attention to the traffic forecasted at the time of decision-making is critical as traffic volume generally follows a time sequence (Flyvberg *et al.*, 2006).

3.3.4 The people involved

The quality of a feasibility study is defined in part by the people involved (Mackenzie and Cusworth, 2007). When competent personnel who are experienced and knowledgeable in conducting feasibility studies are involved, higher accuracy is achieved (Hyari and Kandil, 2009). In addition, having the feasibility process and analysis reviewed and audited by individuals who are not directly involved in the project (stakeholders) is necessary in order to have an unbiased assessment of costs and benefits (Hyari and Kandil, 2009). It is beneficial to take an outside view to help to reduce errors that result from optimism bias.

The quality of the feasibility study may be influenced by bias. Bias may be introduced in the feasibility study, either optimistically or unknowingly by the evaluators (Flyvberg, 2011). Optimism bias is one of the factors that affect the quality of feasibility studies (De Reyck *et al.*, 2015). Poor feasibility study outcomes can manifest bias (general tendency of deviation in a specific direction) and/or imprecision (general tendency of a large spread or deviation from the mean), which pose problems to the validity of subsequent decision support based on such erroneous studies (Nicolaisen *et al.,* 2012).

The outcome of a feasibility study may also be influenced by an owner when the project is being defined as to what it should and will be. There is the tendency of individuals to expect better than average outcomes from their actions and this can lead to overestimation of project benefits and underestimation of projects costs and life (De Reyck *et al.*, 2015). In a bid to make projects more attractive or become feasible by all means (even when it may not work), there is a tendency to manipulate results to suit specific interests (Flyvberg, 2006). However, when proper risk assessments are conducted, the need for optimism bias is eliminated and studies are indeed quite accurate.

Further, involving many stakeholders in the feasibility study process increases credibility of the outcomes and subsequently acceptability of the project while in operation. Active participation of all stakeholders ensures that concerns are incorporated as much as possible in project selection and this contributes to the acceptability and support of selected projects (Dey, 2001; Valentin *et al.*, 2012). Public involvement increases general awareness and acceptability of the project, and ensures meaningful participation, which is central to good decision-making (Naser, 2012:236). Supporting these views, the OECD (2017:10) added that dialogue with end-users should be done early in infrastructure project planning to ensure good performance.

In summary, the people involved, including competent personnel who have experience and knowledge of preparing execution plans and conducting feasibility studies should be involved; independent reviewers and auditors (scrutiny by experts or specialists) who do not have interest in the outcome of the study or the end product (infrastructure project outcome); and team members including a representative of the future operators and stakeholders (Mackenzie and Cusworth, 2007; Hyari and Kandil, 2009; Flyvberg, 2011).

3.3.5 Feasibility study procedure followed

The feasibility study procedure followed has a significant impact on project performance (Mackenzie and Cusworth, 2007:3). Poor forecasts could represent a lack of understanding of the basic underlying process involved in conducting feasibility studies (Hyari and Kandil, 2009). Procedures followed include adequate time to conduct the study without pressure to skip any of the stages/steps in the process, identifying and evaluating alternatives (Beria, 2007; Hyari and Kandil, 2009).

A feasibility study of high quality, whereby all the important phases (concept, prefeasibility and definitive feasibility) are traversed, delivers maximum value (Mackenzie and Cusworth, 2007:3). The various phases of a feasibility study provide different answers to specific questions. For instance, in the scoping phase, the question, “does it make sense to pursue this opportunity or investment?” is asked. In the prefeasibility phase, the questions asked may include: “have enough alternatives been analysed and has the optimum combination of risks and reward or costs and benefits been identified; while in the definitive phase, “what risks will the project involve, what rewards will the project provide, and has a case been presented that is unlikely to vary significantly?” are pondered. Therefore, if a phase in the feasibility procedure is skipped or not properly undertaken, chances are that value may be destroyed since some of the questions will be left unanswered (Mackenzie and Cusworth, 2007:4).

In summary, feasibility studies consider a variety of factors including technical, strategic, financial, legal, and social factors and they must involve the right people and procedures. Hence, the first research question in the current study was posed as follows: What critical factors should be considered for a comprehensive feasibility study?

3.4 INFLUENCE OF FEASIBILITY STUDIES ON SUSTAINABILITY OF TRANSPORTATION INFRASTRUCTURE PROJECTS

The sustainable performance of infrastructure projects depends on feasibility studies made in support of the projects ahead of project implementation. Some of the factors which influence project performance emanate from uncertainties regarding the differences between the forecasted and actual costs, benefits (revenue and satisfaction to the stakeholders) and impacts (Parthasarathi and Levinson, 2010; Glaister *et al.*, 2010).

Comprehensive feasibility studies are essential considerations in effective and efficient allocation of scarce resources and helps in making sound decisions, which lead to reduction in probable financial and economic risks in the long run (Al-Masaeid and Al-Omoush, 2014:319). Inaccurate and inadequate feasibility studies represent major risks in infrastructure planning because the over-estimation or otherwise, may result in inefficient resource allocation and unsustainability of projects. Further, revenue loss from unexpected revenue shortfalls makes it impossible for investors to recoup their capital investments. A concessionaire, for instance, needs to know that there will be assurance of cash flow with an acceptable and affordable tariff while at the same time striving to finance its obligations and still maintain a profitable rate of return (World Bank, 2016). Consequently, studies have been conducted on the relationship between feasibility studies and sustainable performance of infrastructure projects.

Kaare and Koppel (2012) compared performance management approaches used in feasibility studies for projects in extant literature with practices in Estonia and acknowledged a relationship between feasibility study methods used and performance outcomes only. However, the study by Kaare and Koppel did not reveal the relationship statistically and the focus on the methods only may not be comprehensive.

In similar studies, Parthasarathi and Levinson (2010:1) and Liyanage and Villalba-Romero (2015:140) revealed that traffic demand factors omitted in forecasts could result in underestimated costs and overestimated benefits which in turn are detrimental to transport projects while in operation. Lower than predicted revenues, from less than expected passenger traffic, frequently place project viability at risk and redefine projects that were initially promoted as effective vehicles to economic growth as possible obstacles to such growth (Flyvberg *et al.*, 2003). If proper risk analyses are not conducted, including all possible risks and uncertainties, which potentially threaten the sustainability of proposed projects, costs may be underestimated (Macdonald, 2007). This may result in consequences that are detrimental to the economic and social viability of the projects in terms of return on investments (expected revenue) and expected benefits accruing from the project, which in turn determine the level of acceptability of the project (Van der Westhuizen, 2007). Therefore, high estimation errors lead to either inefficient high level of congestion (especially in the case of road projects) or politically untenable levels of underutilisation, which then require contract renegotiations and flexibility of concession period for cost recovery to restore financial equilibrium (Okoro, 2016:486).

Traffic levels, especially in the case of toll roads (whereby the repayment of loans relies on precise traffic estimates), if not accurately estimated, could result in severe financial default since toll roads are often financed through loans that are secured against future toll revenue only and with no other collateral, as opined by Welde and Odeck (2011:81) in their Norwegian study. According to Welde and Odeck (ibid.), if traffic levels turn out be significantly lower than the estimated, the total benefits derived from time savings and reduced accidents can be affected. On the other hand, the capacity relief on the congested links could turn out to be lower than planned, which may distort the viability of the project. However, none of these studies investigated the question of comprehensiveness of feasibility studies and impact on the sustainable performance of the projects.

In Canterelli *et al.* (2010), it was revealed that misleading and inadequate feasibility studies are partly the culprits in the failure of large-scale infrastructure projects. The authors noted that social opinion and intervention by interest groups and stakeholders of proposed projects influence the outcome of projects. Other studies contend that feasibility studies have an impact on the sustainability of projects and economic, social and environmental sustainability is hugely affected (Shen *et al.*, 2010; 2011). However, these studies did not establish what a comprehensive feasibility study should look like and did not investigate the actual performance of projects while in operation.

However, one study which statistically investigated the relationship between infrastructure planning (feasibility study) and outcome (sustainability) found that there is indeed a link between the variables (Dong *et al.*, 2018). The study evaluated the impact of a variety of socio-economic, meteorological and environmental constraints on water supply system sustainability scores and efficiency indicators using k-s test, m-w tests. However, Dong *et al.*'s study focused on network performance and environmental sustainability, but did not consider the financial sustainability aspect of the project.

On their part, Marcelo *et al.* (2016) opined that understanding the factors in feasibility studies is critical in prioritising investments and that choices made at the planning stage have major implications for sustainability. Likewise, Kuhi *et al.* (2015:1349) supported that unreliable and inaccurate feasibility studies result in grave predictions of performance. However, no statistical relations were established in these studies.

In summary, using incomplete data leads to incorrect decisions, which can be avoided through better planning and attention to identifying all potential factors concerning the proposed projects. The critical stage of feasibility studies is very important. Taking cognizance of the factors incorporated in the studies is even more important. Comprehensive feasibility studies, which identify all key factors, improve project performance in the long run. Equally, to ensure good quality feasibility studies, it is important to involve the right people and follow the correct procedures in order to ensure that all the bases and factors that may affect the project during the operational stage, are covered.

3.5 CHAPTER SUMMARY

The present chapter reviewed existing literature on the concept of feasibility studies and the factors that influence the quality of feasibility studies. The relationship between feasibility studies and sustainable performance of transportation infrastructure projects was also reviewed. The synthesised literature revealed that comprehensive feasibility studies are vital in transportation infrastructure planning in order to realise desirable performance. More costs are incurred to remedy the consequences of poor quality feasibility studies and this leads to wastage of public resources that could have been channeled to other productive purposes. Without good feasibility studies, the sustainability of transport infrastructure investments will be unlikely. In other words, the ability of a project to continue to maintain its operations, services and benefits to an investor during its life cycle partly depends on the feasibility studies put forward at the time of planning and decision making. Therefore, conditions and strategies necessary to reduce the risks on projects need to be identified and planned for to ensure sustainability. In other words, the continual performance or sustenance to perform and deliver as expected should be the ultimate concern when transportation infrastructure developments are planned.

Key factors of feasibility studies were identified from literature. These included availability and sources of data, the methods used, and criteria factors such as technical, social, environmental, and economic factors. These factors were observed to cover all possible elements which could affect the performance of the projects while in operation. These findings informed the development of the tools for empirical data collection. Questions for the qualitative enquiry, which followed proximately, were developed based on the specific research objectives for the multi-case study enquiry. Therefore, the specific research questions for the qualitative phase, as presented in section 1.4.3, were: how were the feasibility studies conducted; what factors were incorporated; and how are the projects performing during the operational stage? The succeeding chapter details the methods employed to refine, validate and test the relationships theorised.

CHAPTER FOUR

RESEARCH METHODS

4.1 INTRODUCTION

The present study endeavoured to establish the relationship between feasibility studies, quality influencing factors and project sustainability. To achieve this overall objective, information on feasibility studies, critical factors in transportation infrastructure feasibility studies, the role and impact of feasibility studies on transportation infrastructure project sustainability, was sought. The theorised model was thereafter evaluated using structural equation modeling (SEM).

Data was collected using mixed methods including multi-case qualitative phase to refine the theory developed from the literature review, and a subsequent quantitative survey. The current chapter presents a discourse on the rationale behind the research approach. The chapter demonstrates how the research was designed, what data was collected, and the tools, which were used to collect and analyse data.

4.2 RESEARCH DESIGN

In order to achieve the objectives of the current study, mixed-method sequential exploratory approach was used to develop multiple perspectives and to best answer the research questions (Johnson *et al.*, 2007:125). A three-stage process was adopted. The first stage involved a review of literature about the problem and the feasibility study concept itself. The literature review informed and guided the focus during the second phase of the study. The second stage involved empirical data collection using multi-case studies to establish the practice of feasibility studies as well as project performance. Document analysis and interviews were undertaken. The output from thematic content analysis of empirical data from the multi-case study and literature review integration was a refined framework on feasibility studies. Therefore, the multi-case qualitative phase was used to identify variables and develop a tool for the next phase of the study (Tayie, 2005:53; Ivankova *et al.*, 2006). The theorised framework was tested through a questionnaire survey using different data set and sample. Empirical data from the questionnaire survey were analysed using SEM to determine whether the model from the first and second stages fit the output model from the SEM. This pragmatic approach of using mixed methods is supported by Creswell (2003; 2014), as the research was problem-centred and real-world practice oriented. The research design is summarised in Table 4.1.

Table 4.1: Research design

Stages		Data collection methods	Data analysis techniques	Outputs
1	Literature review	Desktop; review of extant literature	Literature distillation and synthesis	- Background to the study - How feasibility studies are undertaken - Attributes of comprehensive and quality feasibility studies
2	Multi-case (qualitative) study phase	Document analysis and interviews	Thematic content analysis, coding and categorising with the aid of Atlas-ti software	- Themes on who conducted the feasibility studies, what data were used, what methods and processes were employed, what factors were considered in evaluation of projects' feasibility - Themes on performance variables and current performance of selected projects - Theoretical model of feasibility study factors and project sustainability measures
3	Quantitative phase	Questionnaire survey among project participants	Descriptive statistics	- Predominant TIFS factors
			Exploratory factor analysis (EFA)	- Refined model of TIFS factors - Refined model of feasibility study quality (FQ) measures - Refined model of project sustainable performance (PS) measures
			Confirmatory factor analysis (CFA) and Structural equation modeling (SEM)	- Impact significance of TIFS on FQ; - Impact significance of FQ on PS; and - Impact significance of TIFS on PS. - Fit of the TIFS model - Validated conceptual TIFS model for transportation infrastructure project sustainability

4.3 RATIONALE FOR THE RESEARCH DESIGN ADOPTED

4.3.1 Rationale for mixed-methods research approach

The rationale for the mixed research design for the current study was the need to achieve reliability and validity of the study as well as the need to have a study that is grounded in actual practice as opposed to theoretical conceptions. Therefore, the use of mixed methods enhanced transparency and reliability of the results. Further, since the research questions in the current study encompassed a mixture of "what", "how", "why", as well as "how much", a range of data collection methods (qualitative and quantitative) was believed to be suitable (Ghauri and Firth, 2009:31). In addition, mixed methods were used to add breadth and explanations as well as to validate findings from the first and second stages of the research, and ultimately to achieve the objectives of the study (Johnson *et al.*, 2007:122).

Qualitative data collection techniques were employed at the multi-case study stage to understand and analyse (in-depth) the phenomenon of feasibility studies in its ecologically real-world context in which they occur, in a way that cannot be captured using measurement scales (Castro *et al.*, 2010:343; Alshenqeeti, 2014:39). The qualitative approach was also included because it provides clarification and elaboration on ideas regarding what informs a comprehensive feasibility study and its impact on project sustainable performance.

Undertaking the subsequent third phase of the study using a questionnaire was important in order to reliably assess the strength of associations between and among key categories and constructs established from the qualitative phase (Castro *et al.*, 2010:343). In addition, using quantitative research methods afforded the researcher the opportunity to conduct group comparisons, operationalise and measure specific constructs and test hypotheses (Castro *et al.*, 2010:342). Although, it is acknowledged that measurement using quantitative approach typically detaches the information from its original real-world context, this shortcoming was taken care of in the current study by the mixed methods. In addition, the questionnaire items were closely aligned to the interview questions to provide validation (Harris and Brown, 2010:5).

4.3.2 Rationale for exploratory sequential approach adopted

In this mixed-methods sequential exploratory study, important considerations were made regarding implementation (employed sequence of procedures), integration (connection of the two phases) and priority (which method is given more emphasis or attention in the study). The qualitative phase was implemented first to identify important feasibility study concepts and factors incorporated in such studies, based on distinctive theoretical and practical perspectives from document analysis and interviews of professionals involved in the feasibility studies (Johnson *et al.*, 2007). Subsequently, a field survey questionnaire (quantitative phase) was developed using themes emerging from the document analysis and interviews (in conjunction with the findings from the literature review), to validate the refined framework on the factors that are considered in feasibility studies as well as the impact of a comprehensive feasibility study on the performance of projects. The sequential exploratory approach, implementing the quantitative after the qualitative research, was necessary to refine theory and subsequently, validate and test the impact of feasibility studies on transportation project performance. Thus, the results from the qualitative multi-case study (in conjunction with the theoretical findings) phase informed and guided the data collection in the second quantitative phase, and the developed theories were refined, to be subsequently tested using survey research in the quantitative phase (Darke *et al.*, 1998; Castro et al, 2010). Hence, the integration of the two phases occurred in the intermediate stage in the current study as the quantitative phase was based on the results from the first, qualitative phase (Ivankova *et al.*, 2006).

With regard to priority, the multi-case qualitative and quantitative phases were given equal priority as they gave unique contributions to the study with regard to developing and refining, as well as testing and validating the theories, respectively. The qualitative phase explored the views of participants and analysed documents on the feasibility studies conducted on selected projects in order to build and refine theory; whereas the quantitative phase used evidence from the qualitative phase to test and validate the theoretical relationships hypothesised.

4.3.3 Rationale for multi-case study qualitative approach (second stage)

The multi-case study approach was adopted to generate in-depth, multi-faceted understanding of the complex issue of feasibility studies in its real-life context (application on transport projects), as suggested by Crowe *et al.* (2011:100). The import and theory regarding feasibility studies and their multi-facets were defined and refined using constructs identified from literature review, in order to test and validate the theory. Thus, the multi-case study approach was used to build on the existing theory and further refine theory based on the knowledge and provide evidence available in the cases studied for hypothesis generation (Darke *et al.*, 1998:275). The multi-case study approach was also suitable because case studies can be combined with other research methods in studies where there is more than one research objective, such as the current one, which involves validation of the conceptualised feasibility study model for sustainable performance of transportation infrastructure projects (Darke *et al.*, 1998:276).

A case study can be a method of analysis and a specific research design for examining a problem, both of which are used to generalise across populations in most cases (University of Southern California (USC), 2018). A case study approach can offer additional insights into what gaps exists regarding a phenomenon (Crowe *et al.,* 2011), and in this case, in the delivery of transportation infrastructure, with regard to feasibility studies at the planning stage.

Although the case study approach has been criticised for being biased or having the possibility of selecting "wrong" cases resulting in lack of theoretical generalisations, these shortcomings were overcome to a great extent by including multiple cases (more than one), in order to achieve generalisation (Crowe *et al.*, 2011:107). In addition, the lack of rigour, which is usually inherent in case studies, was mitigated by triangulation (using more than one investigation technique including document analysis and interviews as well as thematic content analysis with the aid of the atlas-ti software) (Crowe *et al.*, 2011:107). Triangulating the findings using multiple sources produced a more holistic, complete and contextual picture of the matter being studied (Ghauri and Firth, 2009).

Multi-cases investigate a particular phenomenon (or group) at a number of sites or instances to enhance generalisability (Stewart, 2012:69). Thus, generalisability was improved, when additional cases confirmed findings in different settings and strengthened the results in a way that multiple experiments do in experimental research (Darke *et al.*, 1998:278). Multi-case studies allow cross-case analysis and comparison and the investigation of a particular phenomenon in diverse settings (Darke *et al.*, 1998:277). Cross case analysis, which is possible in multi-case studies, entails a variety of techniques and devices to manage and present the qualitative data as evidence from individual cases are summarised and coded under broad thematic headings and then summarised within themes and across studies, to identify commonalities and differences (Ayres *et al.*, 2003:876; Cruzes *et al.*, 2014). In addition, it was possible to point out and compare the attributes that were common to the cases in order to build theory, which could not have been possible with single cases (Ghauri and Firth, 2009:30). Moreover, thematic analysis can be integrated in multi-case studies, with cross-case analysis, in order to identify recurrent themes or issues arising from a large body of evidence. In addition, with cross-case analysis, it was possible to reduce the evidence to a smaller number of dimensions, present differences between the studies and analyse how the themes relate to one another (and work together in actuality) in a conceptual map (Ayres *et al.*, 2003; Cruzes *et al.*, 2014).

The current study therefore involved data collection on multiple cases (projects) through various sources including face-to-face interviews as well as analysis of feasibility study and performance or progress reports on identified transportation infrastructure projects.

4.3.4 Rationale for quantitative research in the third phase

Stage three of the research entailed collecting empirical data using a questionnaire. The quantitative phase of the study was necessary in order to test and validate the theory developed from the literature review and refined from the multi-case study phases. The quantitative phase was used to collect empirical data for statistical analysis in order to test the hypothesised relations between transportation infrastructure feasibility studies (TIFS) and project sustainability and to validate the TIFS model.

4.4 THE DATA COLLECTION PHASES

4.4.1 Phase 1 - Literature review

A detailed literature review was conducted at the initial stages of proposal development and consolidation to inform the researcher about existing knowledge in the subject area, identify gaps (that case study could help to fill) and support identification of specific research questions (Rowley and Slack, 2004:31; USC, 2018). Extant literature was critically reviewed to provide a solid theoretical foundation for theory development, close areas where a plethora of research exists and identify areas where research was needed (Levy and Ellis, 2006:183; Bandara, 2015:155). A thorough literature review was also crucial in order to ensure that the assumptions made about the need to reveal new insights to feasibility studies and previously non-tested (statistical) relationship between feasibility study and sustainable performance of transportation infrastructure projects was valid and evidence-based (USC, 2018).

The literature review drew on different types of sources including accredited academic and professional journals, books, government reports, organisations' publications, newspapers, magazines, theses and dissertations. Various databases were used including Google, Google Scholar, UJoogle, Science Direct, Emerald Insight, Refseek, Taylor and Francis, Academic Search Complete, ASCE, and Sage. Computer databases were used because they offered access to vast amounts of information, which could be retrieved more easily and quickly than using a manual or physical library search (Ramdhani *et al.*, 2014).

Materials for the core theory of the study mostly spanned a period of ten years. The span was necessary in order to provide current views on feasibility studies and project performance criteria. The wide span was also necessary in order to assist in determining and/or defining the research questions and hypotheses for the main study, from a wide body of knowledge (Ramdhani *et al.*, 2014). The keywords used for the searches include feasibility study, project performance, transportation infrastructure, sustainability, construction industry, and infrastructure projects. These were used in conjunction with influencers, criteria, factors, and indicators, in order to obtain relevant and specific information necessary to develop and demonstrate the relationships considered in the study.

Following a detailed literature review, draft structured interview and questionnaire schedules were initially constructed and pilot-tested in order to test the structure of the tools in terms of wording and length.

4.4.2 Phase 2 – Multi-case qualitative study

4.4.2.1 Pilot study

Prior to the main study, a pilot study, entailing interviews and a questionnaire, was conducted using questions structured from the literature review. The pilot study was conducted using five potential respondents. The results of the pilot study were not presented in this report because significant changes (additions) were made to the structured questions because the questionnaire was too long and contained repetitions and unsuitable responses in some sections. The pilot study therefore served to identify the relevance and simplicity of the questions to avoid misunderstanding and to reduce the number of items. Further, the pilot study served to identify potential sources of information (documents and participants) for the main study. Documents/reports were initially sought from relevant government bodies mentioned earlier, in possession of feasibility documents for transportation projects.

In addition, the pilot study helped to identify problem areas, issues which may have been missed on the feasibility study variables identified from literature review, as well as potential challenges in collection of data, especially with regard to protocols and response rate (van Teijlingen and Hundley, 2001). As sensitive information was required (feasibility reports), the pilot study helped to identify protocols prior to implementation of the full or main study, including approval processes. An introductory letter (Appendix I) was issued by the researchers' Head of Department and supervisor and this was produced at the pilot study stage and throughout the data collection process. Subsequently, permission to access feasibility study and performance reports was granted by different entities including the Gauteng Province Department of Roads and Transport (GPDRT), Johannesburg Roads Agency (JRA) and City of Johannesburg (COJ). These were presented in Appendix II. In addition, a non-disclosure agreement was signed with the Gautrain Management Agency (GMA) during the qualitative data collection phase.

4.4.2.2 Document analysis

Document analysis was employed, alongside interviews as a starting point of investigation, because actual feasibility study and performance reports provided information about the phenomenon being studied. Although time consuming and bias-potent, document analysis was still considered as a suitable method for the current study because it is unobtrusive in nature (naturally-occurring), reduces social desirability bias among respondents when researching sensitive topics (as is the case with focus groups), and can cope with large amounts of data (Rose *et al.*, 2015:7). In addition, it is cost effective (Ahmed, 2010:1).

Document analysis was therefore used to gather qualitative data to gain understanding and empirical knowledge as well as elicit rich information regarding how feasibility studies were conducted and performance of the projects (Bowen, 2009:27). The critical factors which should be considered in a comprehensive feasibility study were sought. The feasibility study or project initiation reports were therefore assessed to identify factors considered during the feasibility studies, the structures and processes that were in place (such as, who conducted the feasibility, and who reviewed and audited the outcomes, if applicable), the methods and data used or referred to during the feasibility studies. The performance or progress reports were also inspected for information on how the projects were performing in terms of sustainability and achieving intended objectives for which they were built.

The projects whose documents were analysed in this multi-case study phase were selected using purposive sampling technique, also known as judgement sampling. This technique was used because it was observed to be appropriate in situations where exploratory data are sought for specific information to incorporate in designing questionnaires (Tayie, 2005:32). Projects that were in operation for more than one year were selected from the databases of identified government entities, to examine the actual feasibility reports. Projects were included based on their being in operation for at least one year because the projects would have matured and stabilised enough for a reliable assessment of performance to be made. Such projects must have been in operation long enough to give an indication of security of returns and feedback from users, for instance, as supported in studies which opined that using projects in their first year of operation is not adequate since they may not have begun to accrue expected returns to the investor (Liu *et al.*, 2010; Siemiatycki, 2010:31; Flyvberg *et al.*, 2014; 2016). Thus, the projects included in the current study were believed to have rich-enough data available to make reliable analysis and conclusions. The purposive sampling therefore enabled inclusion of projects selected on the basis of this specific characteristic and eliminated those who failed to meet the criteria (Tayie, 2005:34).

To select particular projects that met the one-year requirement for inclusion in the current study, government publications were sought, with advice from some of the potential respondents in government departments, which were approached during the pilot study. The publications perused included the Annual Report 2014/2015 of the GPDRT, the Provincial Land Transportation Framework (PLTF), the Medium Term Strategic Framework (MTSF), and the 25-year Integrated Transport Master Plan (ITMP25). The government entities from where data were collected included the Gauteng Province Department of Roads and Transport (GPDRT), the Johannesburg Roads Agency (JRA), the Johannesburg Development Agency, and the Gautrain Management Agency. The SANRAL and PRASA were approached, but feedback was not received from these entities within the scheduled time. The City of Johannesburg's Department of Transport was also approached. However, the projects which were accessible from their coffers were non-motorised transport (NMT) infrastructure facilities, whose performance data were not availed. The NMT projects were therefore excluded from the study.

The entities were purposively identified and approached because valuable information on feasibility study processes and criteria as well as performance of the projects could only be obtained from their coffers (Cruzes *et al.*, 2014). Obtaining the specifically required information from the relevant sources helped to improve the convincingness (validity of case research) of the study, given that such information could only be obtained from the entities themselves (Stewart, 2012). Given the confidential nature of such information, permission was first granted in writing by the various agencies in order to access the information sought. A non-disclosure agreement was also signed with one of the agencies before confidential documents were availed. For all the projects, but one, included in this study, the researcher was allowed to take the documents out of the premises. This enabled collection of richer data as the researcher was not rushed to view the documents. Thus, the availed documents were studied in detail for relevant information not provided by the participants during the concomitant interviews.

Projects, which were identified included rail, bridge, bus rapid transit (BRTs), upgraded and rehabilitated roads, as well as non-motorised transport (NMT) infrastructure projects (which were later excluded due to unavailability of performance data). It was discovered that no new road transportation project was built in the past 30 years in the Gauteng Province, and therefore upgraded road projects which have been in operation (opened to the public) for at least two years were selected based on accessibility to information on the projects (convenience sampling). Upgrading transforms a project from a lower capacity to really high capacity route (completely different kind of project). Some projects including the Gautrain project, the BRT, the K46 and the City Deep projects were pinned down for investigation during the pilot study; while others came up through snowball sampling during the main study.

Feasibility study documents and reports were provided for a total of ten projects. However, only eight of them were included in the case study research. This was because on the other two projects, which were NMTs, information about their performance was not availed to the researcher. Consideration was made to obtain the performance information from another set of respondents (the users), but the idea was later discarded because it was believed that information from the users only may not comprehensively provide information on some of the aspects considered in the current study, such as financial and economic aspects. Consequently, the NMT projects were excluded from the case study research because sufficient information was not provided by the custodians and professionals related to the projects.

Projects which displayed different dimensions on the type and procurement processes involved (private sector participation) were included in order to obtain a diverse representation of all possible types and attributes to capture all possibilities (Centre for Innovation in Teaching and Research (CITR), 2018). Moreover, the projects included in the study vary widely in nature and thus have different characteristics that are unique to the project types and therefore were deemed representative cases for inclusion in the multi-case study phase (Yun and Caldas, 2009:77; Creswell, 2013:99). Thus, inclusion of a variety of projects was necessary to identify, broadly, what goes into feasibility studies for different types of transportation infrastructure projects to ensure desired sustainable performance during the operational stage. Including projects with different characteristics improved generalisation and reliability of results (Trochim, 2006; Naoum, 2007).

4.4.2.3 Interviews

Concomitantly, interviews were conducted during document analysis to obtain information on the feasibility studies and performance of the selected transport projects. Semi-structured interviews were used to investigate how feasibility studies were conducted and the performance of the selected projects from individuals who were involved in conducting the feasibility studies. Semi-structured interviews were used because there were pre-determined questions established in line with the objectives of the study to which responses were sought to refine the theory from literature review (Whiting, 2008:36). They allowed an in-depth relay of participants' records of events, experiences and thoughts about the feasibility studies and performance of the projects and were therefore neither too rigid nor open (Zohrabi, 2013:256). The semi-structured interviews were therefore, verbally administered, and this provided some in-depth information as opposed to structured interviews with little or no variation and with no scope for follow-up questions to responses that may warrant further elaboration (Gill, 2008:291). The use of a basic checklist however helped to cover all relevant areas. This permitted the interviewer to keep the interview within the parameters traced out by the aim of the study and further provided information which was easier and less time-consuming to analyse than open-ended or unstructured ones (Alshenqeeti, 2014:40). The questions were in line with the stated research questions and were neutral, as much as possible, in order to reduce interviewer bias, as Turner (2010) and Rust and Koen (2011) suggested.

The semi-structured interview guide (Appendix III) sought information regarding feasibility studies and project performance. Specifically, section A of the guide contained demographic information about the respondents and organisation. Section B sought information about the projects they were involved in and regarding which they provided information during the interviews. Section C comprised six questions about feasibility study processes, structures, data and methods used as well as criteria factors considered as they occurred on the projects, while section D contained one question about the performance of the project they were responding on.

The participants employed for the qualitative phase of the study were purposively selected by deliberately choosing respondents based on the virtue of their experience and participation in transport planning and management of the identified/selected projects, as well as their willingness to participate within a specified time (Tayei, 2005:34; Etikan *et al.*, 2016:2). Built environment professionals and stakeholders including planners, clients, engineering and feasibility consultants, transport network project managers, environmental specialists and executive managers, who had been involved in the planning and/or are currently engaged in the management of the projects, were purposively selected for the study. It was observed that the purposive selection of these participants provided reliable information regarding the feasibility studies and performance of the transport projects sampled.

Snowball sampling was also used to identify participants based on subsequent recommendation and referrals from initial experts involved in the same projects. This technique was useful in identifying the participants which were hard to reach and not easily identifiable due to the seldom and confidential nature of feasibility studies (Heckathorn, 2011:356; Dusek *et al.*, 2015:281). Such participants included engineering consultants who actually conducted the studies but were reluctant to divulge sensitive information belonging to the client (the government). Although this limitation presented itself during the main study, as envisaged during the pilot study, it was partly overcome by the fact that the unit of analysis for the current study was "projects" and not "people". In addition, since the custodians of the feasibility study reports were the clients (government), considerable input on the projects were made by government entities, and it was possible to draw important theoretical perspectives sought for the development of the questionnaire. As the sample expanded, the bias from the initial recruitment of subjects (as exists in conventional convenience samples) was attenuated (Heckathorn, 2011:356).

A total number of seventeen participants (for interviews) were included in the qualitative phase. This sample size was believed to be sufficient for this first phase of the study. Although a number of issues can affect the sample size in a qualitative research, for instance, in the grounded theory methodology, the guiding principle is the concept of saturation (Mason, 2010). Saturation is concerned with reaching the point where it becomes counter-productive and that "the new to emerge" from additional projects, does not necessarily add anything to the overall story, theory, model or framework (Mason, 2010). This is a point of diminishing return, where more data does not necessarily lead to more information. In such a situation, the aim of the study becomes the ultimate driver of the project design and sample size saturation estimation (Charmaz, 2006). Thus, in the current study, saturation was believed to have been attained in the qualitative phase when data from the interviewees added no new information to the overall story, since the transport projects which were studies had varying characteristics and provided rich data.

In addition, since the units of analysis in the current study were the transportation projects, it was observed that additional project cases (and interview participants) could not have provided any new (or different) information. Moreover, in qualitative research, sampling is aimed towards theory construction, not population representativeness (Charmaz, 2006:6). The goal of qualitative studies was not to generalise but rather to provide a rich, contextualised description and understanding of the phenomenon under investigation through the intensive study of particular cases (Polit and Beck, 2010). Thus, what was required was one occurrence of a piece of data, or a code, to ensure that it became part of the analysis framework and provide understanding of feasibility study and performance attributes of the projects sampled (Mason, 2010). Saturation can occur among a relatively homogenous population of multiple case studies (more than one project case study) and samples of 12 respondents, where the qualitative research is undertaken with a view to developing a quantitative measurement instrument such as in the current study (Boddy, 2016). The profile of the participants is presented in Table 4.2. They included public officials from GPDRT, GMA, and JRA as well as engineers and feasibility study consultants from three consulting companies as well as one private consultant.

Table 4.2: Interview respondents' profile

S/No.	Organisation	Department in organisation	Position in organisation	Years of experience	Case study project involved	Stage involved on the project
1	GPDRT	Transport Planning and Policy	Deputy Director	10	City Deep freight hub	Planning
2	GMA	Transport Integration and Planning	Executive Manager	20	Gautrain	Planning & Operations
3	GMA	Technical Services	Senior Executive Manager	19	Gautrain	Feasibility study & Operations
4	GMA	Operations and performance	Executive Manager	37	Gautrain	Feasibility study & Operations
5	GMA	Safety, Health, Environment and Quality (SHEQ) Assurance	Senior Manager	9	Gautrain	Operations
6	GPDRT	Transport integration & planning	Engineer	9	BRT	Planning & Operations
7	GMA	Portfolio Management	Senior Manager	12	Gautrain	Operations & Feasibility study
8	GMA	Assets and maintenance assurance	Executive Manager	13	Gautrain	Maintenance & Operations
9	GPDRT	Maintenance Department	Chief Engineer	21	D603 & K71	Project Management (Operations)
10	Gauteng Master plan committee/UJ	Advisory/ Steering Committee on the Gauteng Master Plan study	Strategic Advisor	25	BRT	Planning
11	GPDRT	Transport Planning and Policy	Chief Director	15	K46	Planning
12	GPDRT	Construction department	Project manager	8	D1027 (Cedar road)	Implementation & Operations
13	GPDRT	Design Department	Chief Director Design Engineering Services	10	General	Design
14	A&M Consulting Engineers	Transport Integration and Planning	Senior Transport Economist and consultant	12	BRTs	Planning
15	Zimile Consulting Engineers	Design and Planning	Feasibility study specialist/consultant	12	General	Design
16	Fine Programme Consulting Engineers	Transport planning	Project/Programme Manager	11	BRT - City of Tshwane	Planning (feasibility)
17	JRA	Roads Project Asset Management Systems	Project Manager	22	General	Implementation

The interviews were conducted during the months of May and June 2018. A total of seventeen interviews were conducted in seven organisations. Prior to conducting the interviews, ethical clearance was obtained from the university's Ethics Committee (Appendix IV). Thereafter, appointments were made with the identified potential participants using phone calls and emails. The participants were requested to participate in the study within the specified time frame and willing participants confirmed their availability and suitable date for an interview. Some of the respondents required the consent letters which were issued by their Heads of Department or Human Resources Division in order to participate in the study. These were furnished before the researcher proceeded with the interviews.

Face-to-face interviews were conducted (Hofisi *et al.*, 2014). The face-to-face situation was flexible since it lent itself easily to questioning in depth and detail. In addition, and helped to develop a rapport with the respondents, which was necessary for the subsequent (quantitative) phase. Response rate is higher with face to face interviews than in focus groups or other forms of interviews as it is harder to terminate the interview before all questions have been asked (Tayie, 2005:75). Although, some respondents may have felt uncomfortable to address sensitive topics, politeness routines, non-verbal communication and small talk can lead to respondents to open up more (Oltmann, 2016).

Moreover, the face-to-face mode of interviewing was chosen because data security and management was stronger and more consistent, given the sensitive topic of feasibility studies and confidential reports involved (Oltmann, 2016). Thus, the possibility of compromising respondent confidentiality was extirpated. Although, anonymity was not entirely possible in such face-to-face situations, respondents were assured of anonymity in reporting of accounts.

Further, individual interviews were used, as opposed to focus group with a number of participants, because the views of each participant, on the projects they had individually worked on or are working on, were sought. This would not have been possible with a focus group interview because of the difficulty of getting the same people who worked on the same project at a particular setting, and any one participant cannot be probed to the same degree in a focus group interview (Adams and Cox, 2008:17).

The interviews were conducted at the offices of each participant as was observed to be convenient to them. Although an informal quieter setting could create a productive atmosphere, the researcher made the most of the settings as they were (Meyers and Newman, 2007:13). The office settings, although formal, were suitable for the interviews because there were little or no distractions and this enabled focus and concentration on the participant responses. The quiet setting also enabled recording of the interview. The interviews were recorded using a digital (DS) tape recorder, with the consent of the participants. The use of a digital recorder was easy and effective to register permanent information for future use and it enabled the researcher to focus on the interview rather than taking extensive notes (Whiting, 2008:36). The length of the interviews ranged from 24 to 75 minutes.

Telephonic interviews were further used for follow-up and member checks. The follow-up interviews and member checks did not require the researcher and the participant to be in view of each other (Oltmann, 2016). Telephone interviews were used to confirm and obtain clarification on previous information, for example, on the Gautrain, information on the process of public consultation was obtained for more insight on stakeholder participation on the project. The use of telephonic interviews was given some thought since the researcher was aware that this medium of obtaining information could be preferred by some (given the level of discomfort and intense pressure that respondents might feel in face-to-face settings (Oltmann, ibid.); but not by others (given the sensitive nature of certain pieces of information) (Szolnoki and Hoffmann, 2013). However, since telephonic interviews were only used to confirm previous information, this mode of data collection was observed to be suitable.

4.4.3 Phase 3 – Questionnaire (quantitative) survey

The third phase of the research entailed the use of a questionnaire to collect empirical data to test hypotheses and validate the conceptualised model.

4.4.3.1 Questionnaire design

Closed-ended questions were initially drafted from an extensive review and distillation of literature. Rigorous review of literature was an essential first step as it provided the theoretical foundation for planning and conducting empirical studies (Bandara *et al.*, 2015:155). From the literature review and synthesis, which formed the initial theoretical basis for the study, concepts were developed, specified and translated into themes and variables, which were used to develop draft interview and questionnaire schedules. Both tools were initially developed from the literature review because a concomitant mixed methods research approach was previously contemplated to conduct the study. The interview tool contained structured questions, similar to a checklist, and corroboratively, the questionnaire contained statements to which the respondents were requested to respond to with regard to the elements of feasibility studies and performance variables.

The draft interview and questionnaire tools were first presented to the research supervisors for expert reviews. The supervisors checked that the questions (on the interview schedule and questionnaire) were consistent with the study objectives and the questions reflected what they were purported to measure. In addition, it was observed that the tools were too lengthy and may not achieve a high response rate.

In turn, the questionnaire was presented to a statistician at the university's Statistical Consultation Centre (STATKON) to check the structuring of the questions and ease of analysis of data from the questions as structured. The questionnaire responses, which were a mixture of Likert scales as well as yes or no answers, were observed to be unsuitable as they were structured, and some items needed to be regrouped, as supported by the research supervisors. The questionnaire was thereafter revised and a pilot study was conducted among five potential respondents, who met the defined criteria for participating in the study. Pilot-testing of the questionnaires also enabled identification of measures that lacked clarity, issues which may have been missed, as well as items that may not have been appropriate for the targeted respondents and which may be more suitable for a qualitative enquiry (In, 2017). Pilot studies may be used to explore the suitability and challenges of selected research methods and possibility of achieving desired response rate (van Teijlingen and Hundley, 2001).

Therefore, based on the feedback from the expert reviews and pilot study, a decision was made to adopt the sequential exploratory approach for the study, with the intention of developing a questionnaire from an in-depth multi-case study, and subsequently, refining the final questionnaire with themes emerging from the qualitative phase. Hence, the results of the pilot study were not presented in this report.

Subsequently, the emerging themes from the qualitative phase were analysed, integrated and refined with evidence from the synthesis and distillation of literature and the draft questionnaire was refined therefrom. Each question was attended to and approved by the researcher's supervisors before the final field survey was conducted. Expert reviews of the final questionnaire also served to further identify questions which may be problematic and result in low response rate or poor data quality such as negatively-worded questions (Olson, 2010:295; Gummer and Ruβmann, 2013:6). This enhanced test content and construct validity of the scale, since fittingness and measurement problems were identified prior to the main quantitative survey. Therefore, the emerging themes from the multi-case study qualitative phase were used to develop a model and specify the indicators and measures, which made up the measurable variables in the questionnaire.

The final questionnaire (Appendix V) was divided into four sections, comprising open and closed-ended questions. Section A contained the open-ended questions, some of which sought short answers regarding the respondent's role in their organisation and location of project involved with. The rest of the questions in Section A directed the respondents to select an answer among alternatives, with regard to their organisation, role and stage involved in the particular project for which they were responding on. Section A also contained questions about the project characteristics including the type, extent of works, financing type, contract amount, time allocated to the feasibility study and number of years in operation to date. These were important to establish the nature of the project and the respondent's role and experience on the project.

Sections B to D of the questionnaire consisted of closed-ended questions with multiple response Likert sub-scales. The 5-point Likert scale was deemed suitable in the collection of perception data regarding the feasibility studies and sustainability of transportation infrastructure projects, as was used by Joewono and Kubota (2016) and Yang *et al.* (2016). The Likert scale questionnaire was characterised by its simplicity, ease of analysis, and relatively high scale reliability (Kim, 2000:25). These were used because they were observed to yield higher responses than yes or no inquiry or open-ended questions, from the pilot study. In addition, closed-ended questions reduce item non-response rate and are generally preferred to open-ended inquiry (Reja *et al.*, 2003). Moreover, straightforward analysis of empirical data is allowed with closed-ended questions. A 5-point Likert scale was therefore used for the rest of the sections. The Likert scale contained a response continuum for statements indicating the extent to which respondents agree or disagree with statements that defined the constructs of this study (Warmbrod, 2014:31). Respondents were asked to rate their level of agreement with the statements, from options ranging from 1= strongly disagree to 5 = strongly agree. The Likert scale enabled respondents to inform on their degree of agreement or disagreement on a 5-point scale with scores assigned to alternative responses (Saudi, 2014:161). It also allowed for a middle ground (neutral option) for respondents who may not have felt comfortable answering a particular question or were unsure of how to respond to issues that they considered to be sensitive. Thus, the five-point response scale (strongly disagree, disagree, neutral, agree, and strongly agree) was considered suitable for this study.

Similarly, Section B contained Likert scale questions relative to the quality of feasibility studies. Participants were asked to rate their level of agreement on the occurrence of the statements on a recent project they were involved in. Section C consisted of transportation infrastructure feasibility study (TIFS) factors. Respondents were asked to indicate the extent to which they agreed or disagreed with the statements related to the data used, criteria factors considered and methods employed during the feasibility studies of the projects. However, some questions on expertise were added in this section for a minor study being conducted at the time, due to time constraints.

Section D comprised questions regarding the performance of the projects. Participants were asked to indicate the extent to which they agreed or disagreed with the project performance variables including socio-economic factors, safety and security, financial factors, condition of infrastructure and service quality. The 5-point Likert scale was also used to measure performance of the projects, with higher scores indicating better performance (Saudi, 2014:161).

4.4.3.2 Area of study for the quantitative phase

While the multi-case study phase was limited to the Gauteng province in South Africa, the quantitative phase included all the nine provinces of South Africa. This was essentially done to improve generalisability, which is important in quantitative research in order to increase applicability and trustworthiness of the findings (Yun and Caldas, 2009). The distribution of responses from the provinces is presented in Table 4.3. Respondents in Gauteng recorded the highest response rate (57%), followed by Eastern Cape (11%), Kwazulu-Natal (9%) and Western Cape (8%). Most of the hand-delivered questionnaires was distributed in the Gauteng province, and thus resulting in a high response rate.

Table 4.3: Location of projects

S/No.	Province	Percentage frequency
1	Gauteng	57
2	Eastern Cape	11
3	Kwazulu-Natal	9
4	Western Cape	8
5	Mpumalanga	6
6	Limpopo	2
7	Free State	1
8	North-West	1
9	Northern Cape	1
10	No response	4
	Total	100

4.4.3.3 Sampling in the quantitative phase

With regard to the third, quantitative stage, a questionnaire was distributed among participants selected purposively or judgementally as well as through snowballing. Participants were purposively selected based on their experience and participation in conducting feasibility studies of transportation infrastructure projects. This was necessary in order to collect relevant data useful to achieving the objectives of the study (Yilmaz, 2013). In addition, professionals who were involved in the planning process and had knowledge of how the feasibility study for a particular project was conducted were also recruited to participate in the study.

Respondents were further identified through referrals and recommendations from previously engaged participants (from pilot and multi-case study phase). This was important due to the fact that it was not possible to scrutinise the qualifications or required characteristics of subsequent referred or extended participants, especially with online distribution. Therefore, relationships and networks initially made during the pilot and multi-case study phases were retained for the quantitative phase (Dusek *et al.*, 2015:281). In addition, participants, whom the researcher met while attending conferences were recruited during the quantitative data collection. Recommendations were made to use the cidb contractors register. However, this was not considered because contractors were mainly involved at the construction and implementation stage of projects only and were therefore believed to have limited knowledge of the feasibility study process and subsequent performance of the projects.

Recommendations were also made to include engineering consulting professionals because they were mostly involved in feasibility studies. This suggestion was considered and a google search of engineering consulting companies was conducted to identify potential respondents. However, it was discovered that some engineering consulting companies identified from the google search, were not involved in transportation engineering. Hence, only those consulting engineers who were involved in transportation infrastructure projects were included in the study.

Therefore, the purposive sampling procedure enabled inclusion of relevant professionals who actually participated or who have performed a role in the feasibility study process (either through advisory or oversight), or at different stages of the project (initiation and briefing, concept and feasibility, design development, right through to operation and maintenance) and can therefore respond on the feasibility studies and performance of the projects. Consequently, project managers and advisors were included in the study.

Essentially, participants who were available and willing to participate in the study within the set timeframe (August and September 2018) were included in the study. Therefore, the respondents for the quantitative phase of the study were chosen through expert purposive and snowball sampling techniques, with the intention of amassing data from reliable sources based on their knowledge, experience, and subsequently, availability and willingness of those who meet the defined criteria (Alvi, 2016:30; Etikan *et al.*, 2016:2).

Effort was made to include participants in all the nine provinces of South Africa to ensure representativeness and thus generalisability of the results to a wide population (Polit and Beck, 2010). As stated earlier, effort was also made to include respondents from diverse organisations who were (or are) involved on the project in one way or another at different stages of the projects, as can be seen from the table. It was equally important to include respondents who have been involved at different stages of the transportation infrastructure projects, even though they may have been involved with the same project. It was important to remain impartial and independent during the data collection, which is important in research to enhance the reliability of the results (Zohrabi, 2013).

The sample size for the third phase of the study was predetermined as is customary in studies of this nature (SEM). The rule of thumb based on the ratio of participants to variables, 10:1, is a commonly proposed ratio (Hayat, 2013:946; Hoyle and Gottfredson, 2015:987). Based on this rule of thumb, a total of 210 was observed to be sufficient for modeling using SEM, given that the construct with the highest number of variables was 21 (Hoyle and Gottfredson, ibid.). However, estimations in SEM analyses yield parameter estimates, standard errors and test statistics that have asymptotic properties, and therefore do not entirely depend directly on sample sizes, as do the components of the *F* and *t* statistics used in general linear modeling analyses. Instead, they assume a sample that is sufficiently large to ensure the theoretical properties of the estimates and tests. However, sample sizes as small as N = 50 can produce reliable SEM results with normally distributed data and at least three reliable indicators per factor (Hoyle and Gottfredson, ibid.). The questionnaire was therefore initially distributed to 400 respondents with the anticipation of getting a good response rate (about 55%). This sample size was believed to be appropriate for studies of this nature (employing sophisticated analytical techniques such as structural equation modeling), requiring a range of sample size between 30 to 460 cases (Wolf *et al.*, 2013).

4.4.3.4 Questionnaire distribution

The questionnaires were administered by hand, email and online link (using google form) to participants. The initial number of 400 participants were contacted via email and/or telephone, and requested to participate in the study. Some of the participants were also solicited to distribute to their colleagues who had been involved in planning and feasibility studies of transportation infrastructure projects, which had been in operation for at least a year. The drop-off and collect strategy was also used to ensure that more responses were received (Okoro, 2014). Further, repeated reminders using phone calls, text messaging and emails were made to follow up.

After a month of frequent reminders, a google form was created to help increase the response rate, although there was no guarantee that the online surveys would achieve higher response rates (Nulty, 2008). The link was sent to the previous contacts and new ones. These multiple strategies were necessary in order to reduce non-response rate. At the end of the second month of dissemination and reminders, on the 9th of October, 2018, a total of 132 questionnaires were returned completed. The low response rate (33%) was probably because not too many people were particularly involved at the feasibility stage of the projects. However, effort was made to ensure that the directions were clear and input was required from those who had been involved and/or have knowledge of what transpired during the feasibility studies, either in their capacity as advisors, managers, financiers, or executors. Nevertheless, the obtained responses were observed to be adequate to achieve the objectives of the study. Moreover, effort was made to obtain responses from a variety of entities to increase generalisability and reliability of the results. The profiles of the respondents as well as the projects were presented in Tables 4.4 to 4.12.

The respondents were made up of 69% public and 31% private entity professionals. These comprised professionals from the Department of Roads and Transport, which comprised 22% of the sample; consulting companies, 21% and Municipality, 15%. Two percent of the respondents was from the Department of Transport, Department of Public Works and private lending companies, respectively, while 1% was made up of respondents from commercial bank (Table 4.4). The "other" respondents made up 35% of the sample. These included respondents from SANRAL (6%), Universities (6%), Construction organisations (5%), Transportation and Traffic Technology (TTT) Africa (5%), as well as utility, Transnet, Department of Enterprise, National Treasury, GMA, and Government technical advisory centre which made up 2% of the sample respectively, and Johannesburg Development Agency (JDA), which made up 1% of the respondents.

Table 4.4: Respondents' organisation

S/No.	Response category	% frequency
1	Other organisations (Utility, construction, SANRAL, Transnet, Department of Enterprise, Treasury, JDA, TTT Africa, University, GMA and Government technical advisory centre)	35
2	Department of Roads & Transport	22
3	Consulting company	21
4	Municipality	15
5	Department of Transport	2
6	Department of Public Works	2
7	Private lending company	2
8	Commercial bank	1

With regard to position in organisation, Table 4.5 showed varied responses with directors/deputy director and heads of departments forming the majority (25%) of the responses. Project managers made up 15%. Engineers and safety officers made up 12% and 10% of the population, respectively.

Other positions indicated were executive/deputy managers (8%), development managers/ agents (6%), feasibility study consultants (4%), planners (4%), quantity surveyors (4%), lecturer, senior lecturer and associate professor (3%), and technical assistants on project (2%). Further, construction managers, site agents, researchers, financial managers, technical advisors, community development specialists and estimator and laboratory manager (concrete and earthworks) made up 1% of the sample, respectively.

Table 4.5: Respondents' position in organisation

S/No.	Response category	% frequency
1	Director/Deputy director/HoD	25
2	Project manager	15
3	Engineer (Project, Civil, Traffic)	12
4	SHEQ manager/officer/auditor	10
5	Executive/deputy manager	8
6	Development manager/agent	6
7	Feasibility study consultant	4
8	Planner	4
9	Quantity surveyor	4
10	Lecturer/Senior lecturer/Associate Prof.	3
11	Technical assistant	2
12	Construction manager	1
13	Site agent	1
14	Researcher	1
15	Financial manager	1
16	Technical advisor	1
17	Community development specialist	1
18	Estimator & Lab manager (concrete & earthworks)	1

With regard to responses on the project stage involved in, categorised according to the South African Council for the Project and Construction Management Profession's (SACPCMP) project stages, in addition to the operation and maintenance stage (Table 4.6), the respondents were mostly involved in the concept and feasibility (19%) and project initiation and briefing (18%) stages. Design and development stage made up 15% of the sample, tender documentation and procurement as well as construction and implementation stages comprised 14% of the sample, respectively. Close-out and operation and maintenance stages consisted of 10% of the population, respectively.

Table 4.6: Project stage involved

S/No.	Response category	% frequency
1	Project initiation and briefing	18
2	Concept and feasibility	19
3	Design development	15
4	Tender documentation and procurement	14
5	Construction and implementation	14
6	Close out	10
7	Operation and maintenance	10

The profile of the projects also shows a representative sample, having projects of different characteristics. From Table 4.7, it can be seen that road projects comprised 74% of the sample; rail consisted of 12%; bridge 8%; airport 3% and tunnel comprised 2% of the sampled projects. This indicated that a representative population was obtained, with the respondents having been involved in the different projects.

Table 4.7: Type of project

S/No.	Response category	% frequency
1	Road	74
2	Rail	12
3	Bridge	8
4	Airport	3
5	Tunnel	2

With regard to the extent of works on the project, Table 4.8 showed that 64% of the projects comprised expansion or upgrade projects, while 35% was new and 1% non-response was received on this statement. Expansion projects comprised majority of the projects probably because new transportation projects were seldom constructed. Moreover, it was intimated during the interviews that the expansion projects could involve major works; for instance, to change an existing route from a single to a dual carriageway and therefore, feasibility studies for the projects were necessary.

Table 4.8: Extent of works on the project

S/No.	Response category	% frequency
1	New	35
2	Expansion/upgrade	64
3	No response	1

The types of financing for the projects sampled (Table 4.9) was 76% public, 14% PPP and 10% private. The PPP types included joint venture (8%), build-operate-transfer (4%), other (concession, design-build-operate-maintain, 4%) and design-build operate (2%). Further, on the PPP projects sampled, one investor was involved in 2% of the projects, two in 8%, three in 1% and more than three investors were involved in 6% of the projects.

Table 4.9: Project financing type

S/No.	Response category	% frequency
1	Public	76
2	Private	10
3	PPP	14
3.1	PPP type	
	- Design-build-operate	2
	- Build-operate-transfer	4
	- Joint venture	8
	- Other (concession, design-build-operate-maintain)	4
3.2	Number of private investors	
	- One	2
	- Two	8
	- Three	1
	- More than 3	6

With regard to the contract amount, Table 4.10 indicated that 48% of the projects was more than R100m, 28% comprised of projects ranging from R50m to R100m, while 24% consisted of projects, which cost less than R50m.

Table 4.10: Contract amount

S/No.	Response category (R)	% frequency
1	Less than R50m	24
2	R50 - 100	28
3	More than R100m	48

On the projects, the time allocated to the feasibility studies (see Table 4.11) was less than 9 months for 41% of the sampled projects, while 33% of the projects were undertaken between 9-16 months. On 11% of the projects sampled, the feasibility studies were conducted over more than 32 months. Further, on 9% of the projects, feasibility studies were undertaken between 17-24 months, while 5% of the projects had feasibility study periods of 25–32 months.

Table 4.11: Time allocated to the feasibility study stage (in months)

S/No.	Response category (months)	% frequency
	Less than 9	41
	9 – 16	33
	17 – 24	9
	25 – 32	5
	More than 32	11
	No response	1

With respect to the number of years in operation, Table 4.12 shows that 42% of the projects had been in operation for less than 3 years, 23% for 3-5 years, 17% for 6-8 years, and 18% for more than 8 years. It was important to include projects that had been in operation for a number of years, in order to obtain performance data on the projects.

Table 4.12: Operational period of project (in years)

S/No.	Response category (years)	% frequency
	Less than 3	42
	3 – 5	23
	6 – 8	17
	More than 8	18

4.5 DATA ANALYSIS

Data analysis followed a systematic process entailing analysis of data from the multi-case study phase and subsequently, the questionnaire survey data. The techniques adopted are described in more detail in this section.

4.5.1 Analysis of data from the multi-case study phase

Embedded thematic content analysis was used to analyse data from the multi-case study phase, as supported by Yun and Caldas (2009) and Creswell (2013). This process entailed identifying aspects of each case based on *a priori* codes or framework, and identifying themes unique to each case and across the cases (Creswell, 2013). The *a priori* codes were related to the themes as were in the semi-structured interview guide. The *a priori* codes were developed based on the literature reviewed that demonstrated feasibility elements that were critical to improving the quality of feasibility studies. These initially conceived codes were therefore used as a guide to code the data in the ATLAS-ti software. Therefore, template coding, as opposed to open coding, was used to draw out meaning and sub-themes relevant to the study, from the vast amounts of information amassed, using the purposefully developed framework. This was necessary, in order to frame the data into coherent constructs through application of an established language (Blair, 2015). Thus, this research entailed identifying specific aspects of each case based on the sub-themes (including structures, methods, data, and criteria factors adopted during the feasibility studies). These themes were as identified from the literature review. Therefore, they were pre-conceived themes to which *a priori* codes were assigned as applicable.

The documents obtained from the entities, which included feasibility reports and progress or performance data, were first sorted out into the separate categories (feasibility study and performance). Information sought from the documents included themes on how what structures were put in place during the feasibility studies, who was involved, what factors were considered, as well as what methods and data were used. The documents were then analysed together with interview data from transcripts and researcher's raw notes.

With regard to the interviews, the data included audio recordings as well as raw notes made by the researcher during the interviews. The raw data was scrutinised for important points made or emphasized by the respondents during the interviews, also based on the *a priori* codes developed from the literature review. Scrutinising the raw notes was necessary as the scrawls enabled the researcher to recall what was deemed important in the view of the respondent. Each interview was audio-recorded and transcribed verbatim by typing out in Microsoft word.

Due to the multiple cases included in the study, the thematic embedded analysis was performed at two levels: first, within each case and then across the cases (Ayres *et al.*, 2003:872). First, individual cases were analysed to determine feasibility study factors which were incorporated on each project, as well as how the projects were performing at the time of investigations. These were analysed and presented in network diagrams in the ATLAS-ti interface showing the factors and relations as well for each project (Appendix VI). A sifting process was thereafter undertaken to identify themes and variables that were unique to the cases and also cut across the cases (Creswell, 2013:98). The computer software was utilised to manage, sort and organise the large volume of data amassed, which made it easier to locate and extract quotes and segments of data easily, and thus more flexible, and comprehensive than entirely manual handling of data (Burnard, 2008:430).

Further, possible relationships were identified with the aid of the Atlas-ti software and thus enhancing understanding and explanation as to under what circumstances the theoretical models work or do not across the cases (Ghauri and Firth, 2009:35).

Specifically, the qualitative data analysis using Atlas-ti software entailed the following:

i. The transcribed interviews, raw notes and documents gathered were loaded unto the Atlas-ti software;
ii. Coding categories were developed based on the *a priori* themes, which were in line with the research questions;
ii. The documents were then analysed to identify common themes, which were coded. The codes were obtained by highlighting the relevant text to create and name a code. The results were interpreted and reported using networks (Appendix VI);
iv. The networks were created in the software by using "families" or "nodes", under which the codes were grouped, for instance, feasibility study factors and sustainable performance; and
v. The network diagrams were interpreted with regard to the theorised relationships. The main nodes (feasibility study factors and project performance) were linked with the codes as "as part of" or "associated with" in line with the theorised relationships.

Thereafter, the themes and categories emerging from the cases were compared using cross-case thematic analysis to compare and identify similarities and differences among the case.

4.5.2 Analysis of data from the questionnaire survey

Empirical data from the questionnaire were analysed using the Statistical Package for Social Sciences (SPSS) software, version 25 and AMOS version 25. Descriptive and inferential statistics were conducted.

4.5.2.1 Descriptive statistics

Preliminary analyses were undertaken for screening and cleaning of the data in order to identify errors during data capturing in the SPSS software. Minimum and maximum values were checked. Errors related to maximum scores and unassigned values (for the open-ended questions) were corrected. The data was also inspected for missing data and these were excluded pairwise during the analysis. Pairwise exclusion of cases with missing data meant that the cases could still be included in any analyses for which they have the necessary information (Pallant, 2013:60).

Additionally, tests of assumption for statistical input such as normality, were undertaken to determine the skewness of the data. Skewness values indicate the symmetry of the distribution (Pallant, 2013:59). Histograms and scatterplots were examined. Inspection of the histogram and scatterplots indicated that the data on feasibility study quality and feasibility study elements were not normally distributed; they were negatively skewed, with scores clustered to the right, at the "agree" and "strongly agree" end. Although the histogram showed normal distribution for the data on project performance, results from the Kolmogorov-Smirnov test revealed otherwise (Table 4.13). A non-significant Kolmogorov-Smirnov result indicated normality (Ghasemi and Zahediasl, 2012:487; Pallant, 2013:66). The sub-scales for TIFS, FQ and PS all showed significant values (less than 0.05) and therefore, it was deemed appropriate to conclude that the data for this study was not normally distributed. This was taken into consideration as further analysis progressed.

Table 4.13: Kolmogorov-Smirnov (K-S) test of normality

Sub-scales (total scores)	K-S statistic	df / N	Sig.
Total TIFS measures	.096	116	.011
Total FQ measures	.142	129	.000
Total PS measures	.101	124	.004

Further, the data file was checked for outliers (cases with values well below or above the majority of the cases) using the trimmed mean test. The 5% trimmed mean and mean values for the respective sub-scales, were inspected for similarities. If the trimmed mean and mean values were similar and not too different from the remaining distribution, the outliers could be retained (Pallant, 2013:67). Table 4.14 showed that the 5% trimmed mean and mean scores were not too different and thus outliers were retained for further analysis.

Table 4.14: Trimmed mean test for outliers

Sub-scales (total scores)	Mean	5% trimmed mean
Total TIFS measures	147.31	147.93
Total FQ measures	39.02	39.32
Total PS measures	100.28	100.15

Descriptive analyses were undertaken using mean and standard deviation as well as median and interquartile range, to determine the predominant feasibility study elements for the projects sampled, viz-a-viz the data used, expertise, criteria factors considered, and methods employed. To enable meaningful analysis and interpretation, values were assigned to each response, converted into percentages, and averaged into a composite score (Saudi, 2014). The summation or aggregation of a set of multiple items provided a stable and unbiased estimate from the items comprising the scale (Warmbrod, 2014). These composite scores were then analysed using recommended statistics for interval scale items such as from the Likert scale data. These statistics included the mean and median for central tendency as well as the interquartile range and standard deviation for variability.

- ***The mean***

The mean is the average score obtained from all weighted responses on the 5 point Likert scale, which shows the centre of distribution (central tendency) (Boone and Boone, 2012). The average of the scores on the interval measurement from 1 to 5 points on the Likert scale. However, since the data for this study was skewed, it was necessary to report the median value, which is a non-parametric statistic. This was important because the mean (a parametric statistic) can be distorted when data is much skewed (Pallant, 2013:60). Thus, the median and interquartile range values were used to determine the central tendency and variability in the data for the feasibility study elements.

- ***Standard deviation***

Standard deviation (SD) expresses the variability of data or the dispersion of individual observations around the mean (Barde and Barde, 2012). Thus, a value close to zero indicates that the responses are closer to the mean and thus less variability in opinions of the respondents. The standard deviation is a valid measure of variability regardless of the distribution and thus it was deemed an appropriate statistic to use in the current study (Altman, 2005).

- ***The median***

The median *m* is the probability *pr* of a random variable *X* provided it satisfies the compound inequality $pr(X < m) \leq 0.50 \leq pr(X \leq m*)$ (Holt and Scariano, 2017). This means that 50% of the scores have a value higher than the median and 50% have a value smaller than the median. The median value cuts the distribution in half, that is, fifty percent fall below and above this point (Pallant, 2013:60). In order words, the median is the middle value or the 50% percentile. The median can be used in the same data as the mean and standard deviation, especially when the data is not normally distributed, from a small sample regardless of normality, or has outliers, as suggested by Pupovac and Petrovečki, (2011), Pallant (2013) and Sullivan and LaMorte (2016). The median is usually reported with an indication of the dispersion or spread of the scores as well, using the interquartile rang (IQR).

- ***The interquartile range***

The interquartile range (IQR) is a non-parametric statistic, which shows the range of values within which the middle 50% of the distribution resides, with lower bound first (25%, Q1) and upper bound, third (75%, Q3) quartiles, that is, the distance between the 25th and 75th percentiles (Habibzadeh, 2013:92). With even sample sizes such as the case with the current study, the interquartile range is the difference between the first and third quartiles (Q3 – Q1) (Sullivan and LaMorte, 2016). Therefore, due to the non-normal distribution and presence of outliers, the interquartile range values were also presented in this study, in addition to standard deviation scores, to show the variability in the distribution of data with regard to the feasibility study elements.

The above statistics were used to determine the predominant feasibility study elements as evinced from the data, in relation to who was involved in the feasibility studies, what data and methods as well as criteria factors were considered during the feasibility studies undertaken for the sampled projects. The results were discussed in the accompaniment of tables to reinforce the data.

4.5.2.2 Inferential statistics

The inferential statistics was conducted to determine the relationships between the independent (feasibility study elements) and dependent (project performance) variables, with and without the mediating factor (feasibility study quality). The inferential statistics included exploratory factor analysis and structural equation modeling.

Exploratory factor analysis

An exploratory factor analysis (EFA) was conducted to determine the underlying structures (the most parsimonious) of the variables (of which some may be correlated) to describe the relationships between latent and measured variables (Pohlmann, 2004:14; Hickman *et al.*, 2012). Although another statistical technique such as smart partial least squares (SmartPLS) could have been used to determine the dimensionality or factor structure of the variables, based on adequacy of factor loadings (greater than 0.5), especially since it accommodates smaller sample sizes, the consideration was soon discarded. This was partly because, as advised by the statistician, the number of variables for the current study were too many and thus could not be analysed using SmartPLS. In addition, SmartPLS takes into account the relationship between the dependent and independent variables concomitantly, while reducing the number of variables. Therefore, exploratory factor analysis was undertaken because the aim was only to reduce the number of variables at this stage, without taking into account the relationship between the dependent and independent variables.

Exploratory factor analysis was also used to reduce and refine the large number of related variables to a manageable number, prior to using them in further analysis in the structural modeling (Hooper, 2012:2). A number of methodological and statistical considerations were made, including data inspection for suitability, factor analytic, retention and rotation techniques as well as loading cut-off values (Howard, 2016:52). The considerations and decisions undertaken based on prior theory and methodological logic are discussed hereunder.

- ***Assessment of the suitability of the data for factor analysis***

The suitability of the data for factor analysis was assessed based on sample size requirements, as well as the strength of the relationships among the variables. With regard to the sample size requirements, subject to item ratios of 10:1 is the rule of thumb for determining *a priori* sample size. However, smaller samples of 5:1 or less have been used, but considerably larger sample sizes produce more replicable results (Costello and Osbourne, 2005). Nevertheless, in this study, considering the construct with the highest number of items, transportation infrastructure feasibility study (TIFS), with 17 items, five cases per item (a total of 85) were considered adequate (Pallant, 2013:190). This meant that a total of 132 was adequate. Moreover, Hair *et al.* (2010) suggested that sample sizes should be just 100 or larger. Therefore, based on these arguments, the obtained sample size of 132 was deemed sufficient to achieve the objectives of the study using structural equation modeling.

Further, suitability of data for factor analysis (sampling adequacy or whether the data could factor properly) was statistically examined using the Kaiser-Meyer Olkin (KMO) measure of sampling adequacy and the Bartlett's Sphericity test. These tests determine whether the data is factorable and adequate to proceed with further analysis. The KMO specifically indicates that latent variables may be present and therefore EFA can be performed (Howard, 2016:52), while the Bartlett's Test of Sphericity indicates whether the correlation matrix is significantly different from the identity matrix and therefore factorable (if significant) (Hauben, 2017:7). The KMO value ranges from 0 to 1 and should be greater than 0.6 and the Bartlett's Sphericity must be significant ($p \leq 0.05$) for a good factor analysis (Pallant, 2013:190).

Further, sampling adequacy was assessed using the anti-image correlations. If the determinant of the anti-image correlation matrix is high (for example, it is close to one), it is considered as an indicator of the goodness of a factor analysis solution (Szüle, 2013:149). However, as suggested by Pallant (2013), the anti-image correlation matrix should have diagonals all above 0.5 in order to support factorability of the data set.

However, in addition to the sample size requirement or sampling adequacy, the strength of the data is a key consideration in factor analysis and further analyses. The strength of the inter-correlations among the items was examined by inspection of the correlation matrix for evidence of coefficients greater than 0.3 (Pallant, 2013:190). The matrix contained off-diagonal elements (the negatives of the partial correlation coefficients) and diagonal values (which represent partial-correlation-related measures of sampling adequacy) for observable variables (Szüle, 2013:149). In a good factor model, most of the off-diagonal elements should be small (IBM Knowledge Centre, 2016). Variables with a large number of low correlation coefficient (< 0.30) should be removed as they indicate a lack of patterned relationships; whereas correlations that are above r = +/- 0.90 indicate that the data may have a problem of multicollinearity, and it should be considered whether to retain or delete them before further analysis (Yong and Pearce, 2013:88). If few coefficients above 0.3 were found, factor analysis may not have been appropriate (Pallant, 2013:190).

In addition, the initial estimated communalities were examined. Communalities show the strength of the data set and how much variance in the item is explained by the factor structure. The communality is the variance in the observed variables which are accounted for by a common factor or common variance (Yong and Pearce, 2013:82). The common variance is the square of each factor loading derived from the formula:

$$h_j^2 = a_j^2{}_1 + a_j^2{}_2 + \ldots + a_j^2{}_{\mathrm{m}} \qquad \textbf{Equation 4.1}$$

where a equals the loadings for j variables. Values with low communalities have little influence on the data set in the rotation process and can be dropped. An initial communality of less than 0.4 suggests that the factor may not belong or be related to other items in the structure and it should be considered whether to retain or drop the item (Costello and Osbourne, 2005:4).

The above-discussed criteria used to assess the factorability of the data set are summarised in Table 4.15.

Table 4.15: Cut off values for assessing factorability of data

Indicators	Cut-off value / consideration	Source
Kaiser-Meyer-Olkin (KMO) (ranges from 0 to 1)	Recommended value of 0.6 and above > 0.9 – marvellous, superb ≥ 0.8 – meritorious > 0.7 - 0.8 – acceptable < 0.5 - unacceptable	Pallant (2013:199); Chetty and Dart (2015) Howard (2016:52) Chan & Idris (2017:404)
Bartlett's Sphericity test	Significant ($p \leq 0.05$)	Hair *et al.* (2010); Pallant (2013:199) Yong and Pearce (2013:
Anti-image correlation (individual measure of sampling adequacy	Diagonal cells > 0.5	Pallant (2013); Chan & Idris (2017:404) Hauben *et al.* (2017:7)
Correlation matrix	≥ 0.3 - ≤ 0.9	Szüle (2013:149); Yong and Pearce (2013:88)
Communalities (initial estimates)	> 0.4	Costello and Osbourne (2005:4) Hauben *et al.* (2017: 7)

- ***Factor analytic and extraction techniques***

The factor extraction stage entailed determining the smallest number of factors that can best be used to represent the interrelationships among the set of variables (Pallant, 2013:190). Considerations were made as regards the factor analytic method, which guided the extraction method (Howard, 2016:52). The alternatives included Principal Components Analysis (PCA), Maximum Likelihood (ML) and Principal Axis Factoring (PAF).

Maximum likelihood factoring was chosen to extract the factors. This method of extraction allowed for the computation of a wide range of indices of the goodness of fit of the model and permitted statistical significant testing of factor loadings and correlations among factors (Costello and Osbourne, 2005:1). Although the factors could have been extracted using PCA, which is the default method in SPSS, it computes without regard to any underlying structure caused by latent variables and calculates using all the variance in the manifest variables being used, which appears in the solution (Osborne, 2014:3). Hence, PCA does not discriminate between shared variance and unique variance and this is a problem because when the factors are uncorrelated and communalities are moderate it can produce inflated values of variance accounted for by the components.

Further, PAF could have been used to extract the common factors since it evaluates the underlying structure and can reveal a unidimensional factor structure, with estimates that come as close as possible to reproducing the common variance within a correlation matrix (Hickman *et al.*, 2012; Howard, 2016:53). In addition, PAF was suited for the current study where the assumption of multivariate normality was not met (Costello and Osborne, 2005). However, PAF requires several iterations to arrive at a final solution and interpretability is hampered in the process. In addition, it assumes that unique variances (errors) are normal but does not assume that variables are multivariate normal with linear interrelationships. Therefore, ML, which considers the shared variance, avoids the inflation of estimates of variance accounted for and assumes that individual variables are normally distributed, was chosen. Moreover, the ML allowed for iterative tweaking of the parameters in order to maximize the likelihood of reproducing the population correlation matrix or to minimize the difference between the reproduced and population matrices (Osbourne, 2014:10).

In addition, ML factoring was partly chosen because it generally accommodates normally distributed or significantly non-normal data (Costello and Osbourne, 2005:2). Further, ML was the recommended rotation technique to use when further analysis was to be conducted using SPSS AMOS, which has the ML as the default for fit indices. The chosen likelihood-based method was also adequate to address the problem of outliers and skewness as it replaces ordinary sample covariances with the robust estimates of covariances in SEM analysis (Boomsma, 2000:469; Musonda, 2012:170).

The factor analysis procedure entailed deciding on the number of common factors to retain from the results of the extraction (initial solution) of the feasibility study quality items, the feasibility study elements and project sustainable performance factors. Bearing in mind the goal of dimension reduction and that the factor structure from an EFA is sensible and reliable, all the factors theorised to influence the quality of feasibility studies were used to run the analysis, irrespective of the factor structure outcome (Osborne, 2014:18). The decision on the number of common factors to retain from the extraction was then made based on the following:

- ***Kaiser's criterion*** – In line with Guttman-Kaiser 1956 rule to retain only the factors with an eigenvalue larger than 1 was primarily used. Eigen values are variances in the measured variables accounted for by each of the common factors (Muca *et al.*, 2013:178; Howard, 2014:53). An eigen value greater than 1 is a good lower bound for expecting a factor to be meaningful because eigenvalue represents the sum of the squared factor loadings in a column, and to get a sum of 1.0 or more, one must have rather large factor loadings to square and sum (Osbourne, 2014:18). However, the Kaiser's criterion tends to retain too many factors and thus it was necessary to consider other criteria.
- ***Scree plot*** – An inspection of a graphic representation of each factor with eigenvalues (scree plot) was undertaken. The Catell's 1966 scree plot gave a shape of the curve, which changed direction and became horizontal or flat after the factors that contributed the most to the variance in the data set (Costello and Osbourne, 2005:3; Pallant, 2013:191). Hence, the number of factors above the break or elbow of the scree plot indicated the number of factors to be retained (Hickman *et al.*, 2012).
- ***Percentage of explained variance accounted for (eigen values)*** - The number of factors, that cumulatively accounted for about 70-80% of the variance, which gives the most interpretable solution, were retained.
- ***Communalities (after extraction)*** - After extraction, a relatively high communality is desirable. If the communalities are low, the extracted factors account for only a little part of the variance, and more factors might be retained or deleted in order to provide a better account of the variance. However, as suggested by Field (2005:1), communalities after extraction should be above 0.5 and this cut-off value was adopted in the current study.

- ***Factor rotation and interpretation***

The retained factors were thereafter rotated to enable interpretation and attain an optimally simplified structure, with each variable loading on as few as possible, but with maximum number of high loadings (Yong and Pearce, 2013:84). Factor rotation presented the patterns of loadings, showing which variables clump together, as the axes are being rotated so that the clusters of items fall as closely as possible to them (Osbourne, 2014:32). A factor loading for a variable is a measure of how much the variable contributes to the factor; thus, high factor loading scores indicate that the dimensions of the factors are better accounted for by the variables. (Yong and Pearce, 2013:80).

Rotation methods fall into two broad categories: orthogonal and oblique (referring to the angle maintained between the X and Y axes). Orthogonal rotations produce factors that are uncorrelated (i.e., maintain a 90^0 angle between axes); oblique methods allow the factors to correlate (i.e., allow the X and Y axes to assume a different angle than 90^0). The promax oblique method of rotation was used in this study to clarify factor loadings, much like orthogonal varimax method, such that larger loadings are increased and smaller are minimised. Although orthogonal rotation methods (varimax, equimax and quartimax) could have been used to produce more easily interpretable results, they produce uncorrelated factors (unlike promax rotation) and this leads to loss of valuable information if the factors are indeed correlated (Field, 2005). It was observed the TIFS factors were correlated and the promax was thus suitable for use in the rotation (Hooper, 2012:9). Thus, the oblique method, promax, was used because its parameters allowed correlation to an extent and yields better results than standard varimax rotation (Dien *et al.*, 2005:1812; Osbourne, 2014:32).

Interpretation of the results was undertaken as suggested for maximum likelihood promax-rotated factor analysis. An examination of the factorial loads on the common factors as presented in the pattern matrix was done. Although it is recommended, when using oblique rotation, to interpret the structure (or factor correlation coefficients) matrix as well (which reveals any correlation between the factors) (Matsunaga, 2010:101), only the pattern matrix was examined and interpreted for item loading in the current study. This was because the substantive interpretations were essentially the same (Osbourne and Costello, 2005:3). The pattern matrix was therefore deemed sufficient to identify underlying common factors.

Items with loading of less than 0.4 on all dimensions were deleted, individually, and the rotation was re-run. Factor loadings less than 0.4 indicate that the item was unreliable and as a result may be a candidate for deletion (Hooper, 2012:10). Smaller loadings are allowed for larger sample sizes, according to a rule of thumb (Yong and Pearce, 2013:84). For instance, using an alpha level of 0.01 (two-tailed), a rotated factor loading for a sample size of at least 300 would need to be at least 0.32 to be considered statistically meaningful. Based on this, the current study adopted a cut-off value of 0.5 and dropped factors well below this value in order to improve the strength and reliability of the factor structures. Each item under 0.5 was observed to have low variables and thus suggesting weakness, unreliability or not belonging to the subset and was removed successively. The signs of the loadings (positive or negative) were not considered as they only showed the direction of the correlation and did not affect the interpretation of the magnitude of the factor loading or the number of factors to retain (Yong and Pearce, 2013:84).

Further, the pattern matrix was assessed for cross-loading variables. A cross-loading is when an item loads at 0.32 or higher on two or more factors (Costello and Osborne, 2005). There should be few item cross-loadings (i.e., split loadings) so that each factor defines a distinct cluster of interrelated variables (Yong and Pearce, 2013:84). Ideally, common factors having three or more factor loadings are desirable and should be retained (Costello and Osbourne, 2005:4).

A summary of the acceptable or cut-off values for factor analysis, as were considered in the current study, is presented in Table 4.16. Therefore, items that did not meet the criteria were individually removed and the EFA repeated until all remaining items met the criteria for item retention, as was suggested by Hickman *et al.* (2012). The EFA process is depicted in Figure 4.1. The internal consistency reliability of the sub-scales established after prior to factor analysis and afterwards were assessed using the Cronbach's alpha test, and the results are presented in a later section.

Table 4.16: Cut-off values for factor analysis (retention and extraction)

Indicators	Cut-off value / consideration	Source
Kaiser's criterion	Eigen value greater than 1	Muca *et al.* (2013: 178) Howard (2014: 53)
Scree plot	Number of factors above the break/bend of the curve	Costello & Osbourne (2005:3) Pallant (2013:191)
Variance	> 70	Muca *et al.* (2013)
Communality (after extraction)	> 0.4 - well defined variables > 0.5 - strong variables	Costello & Osbourne (2005:4) Field (2005) Chetty and Dart (2015)
Factor loadings	- Three or more strong factors should be retained; - No cross loadings; secondary factor loadings of 0.3 should be dropped	Costello & Osbourne (2005:4) Chan & Idris (2017:404)

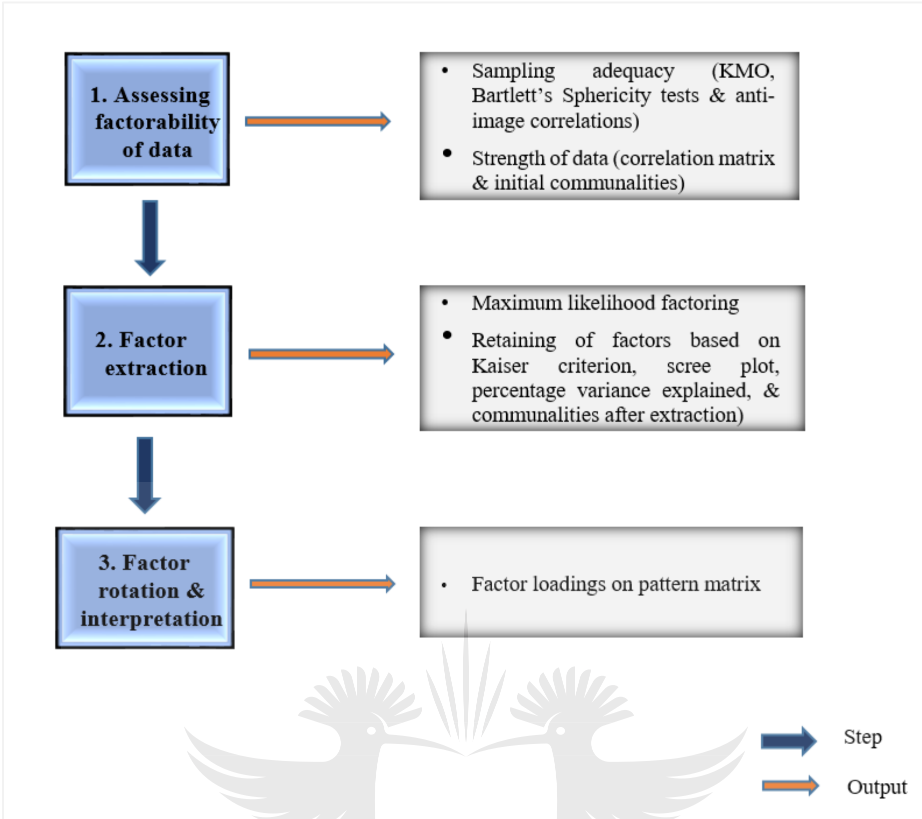


Figure 4.1: Exploratory factor analysis procedure undertaken

Structural equation modeling

Following the EFA, structural equation modeling (SEM) was conducted using the output from the pattern matrix from the SPSS software. Structural equation modeling is used when the goal is to model a structure or process as opposed to isolated tests of individual parameters such as correlation coefficients or mean differences (Hoyle and Gottfredson, 2015:987). It is believed to be more flexible than other analytical techniques such as the multiple regression analysis and partial least squares (PLS). Although PLS had been advocated for non-normal distribution and smaller sample sizes, and accommodates many independent variables even when they display multi-collinearity (Matthews *et al.*, 2018), SEM was still chosen due to its flexibility in handling more data than the PLS. Moreover, PLS only predicts and captures the variance in the dependent variables but does not model coefficients and thus not for theory development or testing (Iacobucci, 2010:94).

Further, although multiple regression analysis could have been used to determine the extent of the relationships, SEM was chosen for the current study because it can establish multiple linear relationships at the same time. In addition, whereas regression models implicitly assume zero measurement error (that is, to the extent that such error exists, regression coefficients are attenuated), error terms are explicitly modeled in SEM and as a result path coefficients modeled in SEM are unbiased by error terms, whereas regression coefficients are not. Further, the flexibility of the SEM permits examination of complex associations, use of various types of data (e.g., categorical, dimensional, censored, count variables), and comparisons across alternative models (Wolf *et al.*, 2013).

Structural equation modeling was conducted using the Analysis of Moment Structures (AMOS) software version 25. The use of SMARTPLS for partial least squares SEM was contemplated for analysis since it could accommodate smaller sample sizes, has a workable interface, does not require normal distribution and could analyse direct and direct effects, even with mediating variables (Hadi *et al.*, 2016). However, the idea was discarded because the model under study had too many variables and could not be handled in the software. Therefore, partial least squares using SMARTPLS was observed to be unsuitable. Further, the use of Python was considered for analysis as it was flexible, could accommodate more programming relationships and features at once, has a clean syntax and easily understandable semantics as well as high computation speed and accuracy (Ekmecki *et al.*, 2016). However, it was observed not to be suitable for structural equation modeling which involves more complex and sophisticated programming and computing of multiple relationships at once (Musonda, 2012).

Therefore, the AMOS software was preferred because its graphical user interface is intuitive (Nokelainen, 2007:3). Moreover, AMOS is able to read SPSS data as an input, unlike the other SEM packages such as EQS, LISREL and MPlus, which requires the data file to be saved into a different file format. In addition, it allowed the use of additional plugins for programming, which simplified the process in lieu of building a series of paths manually (Nokelainen, 2007). Hence, an additional plugin, pattern matrix builder version 25 was used to automatically build the measurement model structure, with output from the EFA pattern matrix.

Structural equation modeling considerations and process

The SEM basically followed the process of model characterising and measurement, model estimation, evaluation, and selection, as advocated by Boomsma (2000:463) and Awang (2012). The structural modeling process was centered on two main steps (validating the measurement model and fitting the structural model (Boomsma, 2000:471; Awang, 2012:62). The first part entails establishing confidence in the measurement model, using confirmatory factor analysis (CFA) (Chinda and Mohamed, 2007:123). The measurement model considers the relationships between the constructs and their indicators, taking into account that these were error-prone. Mathematically, the relationships were modelled as per the equation:

$$x = \lambda.\xi + \delta \qquad \textbf{Equation 4.2}$$

where x is the observed or measured variable, ξ is the latent construct, λ is the factor loading in a regression coefficient (showing the strength of the relationship between a measured variable x and an exogenous latent construct y) and δ is the random measurement error associated with the measured x variable (Bollen and Noble, 2011).

A latent variable is a construct (unobserved, measured, factor) which is a mathematical function of a set of indicator (observed, manifest, measurement) variables. Structural equation modeling rejects models with measures that do not fit or meet some specified cut-off criteria and requires at least 2 or 3 indicators per latent variable (Byrne, 2001:4). A latent variable may be exogenous or endogenous. Exogenous variables have no prior latents, albeit they may be specified as correlated with other exogenous variables. Endogenous variables have prior causes and may be causes of other variables. Mediating variables are also endogenous, being dependent and independent with respect to other variables (Byrne, 2001:5). The resultant structures from CFA were then used for further structural modeling.

The latent constructs were represented with ellipses or ovals, indicators in rectangles and error and residual terms in circles, with straight arrows to its indicators. The single-headed arrows from the respective latent constructs to its indicators are causal relations; while the double-headed arrows are correlations between indicators or between exogenous latent constructs (Byrne, 2001:8). In AMOS, an indicator's path in the path diagram (circles-arrows causal diagram of the model) must be specified as 1 to set a metric for a latent (Crowson, 2016). The model was then specified, fit and modified to establish a valid fit model for the structural model.

The structural model displayed the interrelations among latent constructs and observable variables in the proposed model as a succession of structural equations, similar to running several regression equations (Schreiber *et al.*, 2006:325). Essentially, the structural model showed the relations between exogenous and endogenous constructs, by describing the amount of explained and unexplained variance (Multivariate Data Analysis, n.d.:16; Chinda and Mohamed, 2007:123).

However, prior to the CFA, certain considerations were made to ensure that errors were minimised in the analysis and results. These considerations included data preparation requirements including sample size, missing data, and outliers, theoretical specifications, method of estimation, model fit criteria and modifications.

Data preparation

Data preparation requirements and considerations included sample size, missing data, multivariate normality, outliers. These were taken care of prior to the EFA. These were important considerations since they could affect model assessments and estimations in SEM.

- ***Sample size requirements***

  As was done prior to the EFA, sample size requirements were considered. The rule of thumb of ratio of sample size to number of free parameters was used. Although a sample size of 200 cases is generally the rule, a ratio of 5 to 1 was considered sufficient (with 132 cases) in the current study (Bentler and Chou, 1987; Kenny, 2015).

- ***Missing data***

  Treatment of missing data was contemplated because the chosen method could affect resultant estimates and thus SEM required complete data (Allison, 2003). The ML method of estimation accommodated missing data by estimating means and intercepts in AMOS (Byrne, 2001:296; Carter, 2006:3). However, missing data were still treated in order to enable assessment of multivariate normality and the presence of outliers which affect parameter estimates and model fit gravely (Gao *et al.*, 2008; Wolf *et al.*, 2013; Crowson, 2018). Moreover, in AMOS, the presence of missing data does not allow multivariate tests and other functions such as modification indices and bootstrapping to be performed (Crowson, 2016).

Consequently, a choice was made between listwise deletion, pairwise deletion of missing cases and imputation. Listwise deletion means removing all records with missing data, and assumption that data are missing completely at random (MCAR) (Carter, 2006:1). This can be done when the probability of obtaining a particular pattern of missing data does not depend completely on the missing values or observed data and all cases are then calculated with the same set of cases. However, it was observed that if data were MCAR, they were also missing at random (MAR). Missing at random (MAR) allows "missingness" to depend on things that are observed, rather than things that are not observed (Aguinis *et al.*, 2013). Therefore, it was considered that data were missing at random and the listwise deletion could have reduced the number of cases being examined (sample size) (Byrne, 2001:289). Hence, pairwise deletion was also contemplated.

Pairwise deletion uses all available data and removes particular cases, which have missing data on the variables (Carter, 2006:1). However, pairwise deletion can result in biased estimates (such as the chi-square statistic fit index), greater sampling variance under certain conditions (e.g., regression analysis with high correlations among the explanatory variables) and/or inconsistent standard error estimates (Byrne, 2001:28; Allison, 2003:548). In addition, the pairwise deleted correlation matrix may not be positive definite, signifying that the parameters for many linear models cannot be estimated at all (Allison, ibid.). Thus, the idea of using pairwise deletion was discarded.

Consequently, mean imputation was used to treat missing data. Unconditional mean imputation, which entailed calculating the mean for the non-missing cases and substituting the value for the missing data, was used (as opposed to conditional mean imputation) (Allison, 2003:548). Conditional mean imputation regresses the variable with missing data on other variables for cases with complete data and generates predicted values based on the regression equation. Although the conditional mean imputation method also potentially yields biased estimates of parameters, it was observed to be best suited for this study with smaller sample size and non-normal data.

- ***Multivariate normality and outliers***

Following the treatment of missing data, multivariate normality was assessed and outliers were identified. Multivariate normality and presence of outliers determine the choice of SEM estimation methods and was therefore assessed (Schreiber *et al.*, 2006:327). Although multivariate normality was taken care of by the use of the maximum likelihood (ML) estimation method in AMOS, which accommodates non-normal distributions, the severity of non-normality was checked. Multivariate normality is not assumed with unweighted least squares. Therefore, the ML method of estimation used, which had an additional advantage of accommodating multivariate normality and is the default program in AMOS, which has the least bias, was maximum likelihood (Byrne, 2001).

However, the severity of non-normality was still assessed due to its potential implications on the direction and size of an effect or relationship in SEM (Aguinis *et al.*, 2013). The presence of outliers in the data may distort both the estimated model parameters and the goodness-of-fit of the model (Mavridis and Moustaki, 2008:454). Multivariate normality and outliers were therefore checked and detected using skewness and kurtosis *(Mardia's coefficient)* as well as the Mahalanobis D^2 distance tests (Crowson, 2018). The absolute value of skewness 1.0 or lower indicates that the data is normally distributed (Awang, 2012:72). Kurtosis values greater than 1.96 and large multivariate kurtosis (*Mardia's*) coefficients indicate significant non-normality (Byrne, 2001:277). Further, outliers (data points that markedly deviate from others) and their potential effects on the model were checked using the Mahalanobis d-squared distance test. The higher the value for a case, the more it is improbably far from the solution centroid under assumptions of normality. The approach used was to compare Mahalanobis D^2 distance test, which identifies the squared distance to the χ^2 distribution with p degrees of freedom and declares an observation to be an outlier if its value exceeds the quantile for some inverse probability; i.e., χ^2, p <0.005 (Byrne, 2001; Finch, 2012). Other approaches to handling outliers were also considered. These included the minimum volume and ellipsoid (MVE) and the minimum covariance determinant (MCD). While MVE minimizes the volume of an ellipsoid created by the retained points, MCD minimizes the determinant of the covariance matrix (an estimate of the generalised variance in a multivariate set of data) in an attempt to detect outliers (Finch, 2012). By so doing they tend to identify a relatively large number of outliers when the variables under examination are not independent of one another (Rousseeuw and van Driessen (1999).

Another approach called the forward search was contemplated. This technique required detecting outlier-free subsets iteratively by defining a basic subset and monitoring statistics of interest such as parameter estimates and goodness of fit measures. However, this method still involves reference to the Mahalanobis distance values and likelihood contributions and residuals (Mavridis and Moustaki, 2008). Thus, in essence, it examines the factor analysis estimates in totality without focusing on detecting and deleting outliers first. However, this technique is more applicable with larger data sets where outliers may not have much influence on the estimates.

Therefore, in the current study with smaller sample size, the Mahalanobis D^2 distance was preferable. Moreover, D^2 was easy to compute using the AMOS software and allowed for evident and direct testing regarding outlier status (Finch, 2012). The outliers were thus identified and removed from further analysis. This was done despite the perception that it is not always advisable to delete outliers from a data set because their presence may be informative about the nature of the population in terms of infrequency when compared with the rest (Zijlstraatt *et al.*, 2001). The outliers were still deleted because it lowered univariate and multivariate non-normality (Mahalanobis D^2) and in turn improved reliability of estimates (Gao *et al.*, 2008). Therefore, cases with the highest d-squared values (with p values less than 0.005) were considered as outliers and deleted. The normality test was rerun to check the *Mardia's* coefficient (Byrne, 2001:277; Schreiber *et al.*, 2006:332).

- ***Prior examination of degrees of freedom for definability of the model***

The suitability of the sub-models for identification or definability was further evaluated at the preliminary stage. It was necessary to determine whether it was theoretically possible to derive a unique estimate of each parameter even before SEM analysis is conducted (Musonda, 2012:173). This was done by examining the degrees of freedom. The degrees of freedom *df* is the difference between the number of sample moments and parameters to be estimated, which should be positive (greater than 1) for a model to be considered analysed or defined (Byrne, 2001). It was important to determine whether the model could be defined (analysed) or not because a model could be over-identified, under-identified or just-identified. A model is over-identified when the number of estimable parameters is less than the number of observations (variance and covariances); and under-identified when the model contains insufficient information to produce a determinable estimation (Musonda, 2012:125).

Theoretical specifications

Consideration was made with regard to the theory and relationships underlying the model to be used for SEM analysis. This was important because the accuracy of parameter estimates partly depends of the soundness of the theory and on the validity of the measurement as suggested by Guo *et al.* (2009:4). The EFA conducted at the first stage of inferential analysis elicited factors which could be subjected to further analysis and testing using SEM. Extant literature was consulted to support the outcome of the factor structures which emerged from the EFA after repeated rotations and rename where necessary.

The relationships between the established constructs and measures, which formed the hypotheses postulated in this study were indicated. The empirical frameworks were therefore tested using SEM. The final factor structures (pattern matrices) for the sub-sets of data were subjected to confirmatory factor analysis in AMOS, to output the measurement model prior to structural modeling.

Model estimation

Structural equation modeling uses fitting functions (to transform data into estimates) that minimize the difference between the population and sample (Guo *et al.*, 2009). The main choice of estimation method in AMOS was between maximum likelihood, weighted least squares and unweighted least squares (Guo *et al.*, 2009). In addition to being the default program in AMOS, and the most reasonable estimation method to use following maximum likelihood factoring in EFA, the maximum likelihood estimation method was selected because ML-based fit indices outperform those obtained from generalised least squares tests or other forms of estimators (Hu and Bentler, 1999:5).

The outputs (estimates) for the SEM were specified. These included parameter estimates, fit indices and residuals, standardised estimates and unstandardised estimates as well as direct and indirect effects in the structural model. However, standardised estimates were considered for analysis in the model modifications. This was because standardised estimates show how much variance the predictor variables predict in the latent variable, and thus provide comparability between variables, based on the regression coefficients (Nokelainen, 2007:8). On the other hand, unstandardised estimates only show how much a factor is influenced by an increase in a particular predictor variable (Nokelainen, ibid.).

The standardised residuals matrix was also examined. These showed the number of standard deviations of observed residuals from zero residuals that should exist if the causal model fits perfectly (Byrne, 2001; Schreiber *et al.*, 2006:327).

The outputs from the analysis also included squared multiple correlations (R^2; the percentage variance accounted for by each variable or the fit of separate equations), critical ratios, estimates of fit and standard errors of measurement (Boomsma, 2000:473). For confirmatory factor analysis (measurement model), the estimates interpreted were the variances because the relationships between the latent structures and their indicators were sought; whereas for structural modeling, the regression weights were important since the relations between and among latent structures themselves are modelled (Schreiber *et al.*, 2006; Crowson, 2016).

Model fit analysis

The aim of SEM is to find a model that best fits or represents the data underlying the theory. Therefore, following the specification of indicators and variables, the model fit summaries of each measurement model was analysed. Fit refers to the ability of a model to reproduce the data (i.e., usually the variance-covariance matrix) and therefore a good-fitting model is one that is reasonably consistent with the data (Kenny, 2015). The examination of goodness of fit is somewhat subjective, and the indices vary whether they are absolute of comparative or whether they value parsimony or not (Iacobucci, 2010).

A number of goodness of fit indices and cut-off values were adopted as suggested in extant studies. The use of both absolute fit indices and comparative fit indices was made, as suggested by the authors identified in the table. This was in order to provide complimentary information about the model (Iacobucci, 2010:90). Therefore, a two-index presentation strategy as advocated by Hu and Bentler (1999) was adopted. This entailed inclusion of absolute and comparative fit indices, in order to provide supplementary information, since they are affected by sample sizes, for example, the SRMR and the RMSEA, Tucker-Lewis Index (TLI) similar to the NFI or comparative fit index (CFI) (Hu and Bentler, 1999: Boomsma, 2000:473; Zen, 2007).

Absolute fit indices show how well a hypothesised model reproduces or matches the sample data (Hu and Bentler, 1999; Hooper et al, 2008; Iacobucci, 2010). They show differences between the data and the model predictions. They do not rely on comparison with a baseline model in order determine how well the model fits, unlike comparative fit indices (Hooper *et al.*, 2008:53). The absolute fit indices use the chi-square in its raw form (which is inferential in nature) and modifications of it including RMSEA, SRMR, TLI, GFI and AGFI.

Comparative, relative or incremental fit indices compare the fit of one model to the data to the fit of another model to the same data (Iacobucci, 2010:91). They do not use the chi-square in its raw form but compare the chi-square value to a baseline model; with a null hypothesis that all variables are uncorrelated (Hooper *et al.*, 2008:55). Comparative fit indices are analogous to R^2 and thus a value of 0 indicates a worst fitting model and a value of 1 indicates best possible fit (Kenny, 2015). In other words, the higher the value, the better.

Both absolute and comparative fit indices were therefore used to determine how well the model fits the sample data since they provided complimentary information (Hooper *et al.*, 2008; Iacobucci, 2010:90). Commonly used absolute and comparative fit indices are the chi-square, goodness of fit index (GFI), adjusted goodness of fit index (AFI), root mean square error of approximation (RMSEA), root-mean-square residual (RMR) standardised root mean square residual (SRMR), normed fit index (NFI), comparative fit index (CFI), normed chi-square (NC), and parsimonious fit index (PFI). The following fit indices were considered in the choice of criteria to use for model fit in this study:

- *Chi-square (adjusted by its degrees of freedom)*

  The chi-square statistic is a "badness of fit" measure, meaning that a significant value indicates that the given model's covariance structure is significantly different from the observed covariance matrix (Byrne, 2001:72). Therefore, a non-significant result was desirable. For models with about 75 to 200 cases, the chi square test is generally a reasonable measure of fit (Kenny, 2015). However, there are problems associated with the chi-square. It has a propensity to be too liberal (having too many Type 1 errors), when variables have non-normal distributions or with small sample sizes. Type 1 error occurs when the model is always significant even when it is not true, and with small sample sizes, this type of error is prevalent

(Kenny, 2015). A χ^2 will almost always be significant (indicating a poor fit) even with only modest sample sizes (Iacobucci, 2010:91). Chi square is also affected by the size of the correlations in the model: the larger the correlations, the poorer the fit (Kenny, 2015).

Hence, given that the chi-square is affected by the sample size and size of correlations, the chi-square to differential ratio or χ^2/df was considered. The degrees of freedom [k (k – 1)/2], where k is the number of variables in the model, should be positive (Byrne, 2001:72). A model demonstrates reasonable fit if the chi-square statistic adjusted by its degrees of freedom does not exceed 3.0 (Iacobucci, 2010:91). However, values can range from as high as 5.0 to as low as o.2 (Hooper *et al.*, 2008:54). Nonetheless, other fit indices were considered, including the following, given that the chi-square statistic was prone to errors in relation to sample size.

- *Root mean square error of approximation (RMSEA)*

The RMSEA indicated how well the model fits the population's covariance matrix, with unknown but optimally chosen parameter estimates. The unknown distribution values of the RMSEA allowed for the confidence interval to be calculated around its value, making it possible to test the null hypothesis more precisely. However, it was also observed to be sensitive to the number of estimated parameters in a model as it chooses a model with lesser number of parameters (Boomsma, 2000:473). In addition, models with low degrees of freedom and sample size have artificially large values of the RMSEA, as high as 0.126, exceeding the recommended and acceptable upper limit of 0.08 (Steiger, 2007; Kenny, 2011:5). Other RMSEA ranges and cut-off values have been prescribed: 0.05 to 0.10 (fair fit), above 0.10 (poor fit), 0.08 to 0.10 (mediocre fit), below 0.08 (good fit), close to 0.06 (Steiger, 2007) and upper limit of 0.07 (Hu and Bentler, 1999) as good fit. In a well-fitting model the lower limit is close to 0 while the upper limit should be less than 0.08. Thus, the RMSEA at 90% confidence interval (higher threshold) should be < 0.06 to 0.08 (Schreiber *et al.*, 2006). In the current study with low N (sample size), the RMSEA was not necessarily relied on for model fit.

- *Standardised root mean square residual (SRMR)*

The SRMR is an absolute measure of fit, defined as the standard difference between the observed correlation and the predicted correlation (Kenny, 2011:6). Values here range from 0 to 1.0, but generally, values less than 0.08 are a good fit (Hu and Bentler, 1999; Iacobucci, 2010:96). However, as suggested by Marsh *et al.* (2004:334) and Hooper et al (2008:55), this index is sensitive to sample size, favouring larger samples, with well-fitting models ranging from 0 to 0.5. The SRMR is zero when the model predictions match the data perfectly (Iacobucci, 2010:91). In order words, the smaller the SRMR, the better. Nonetheless, the SRMR should often be reported with other fit indices as suggested by Hu and Bentler (1999). Therefore, it was used in conjunction with other indices, especially given the small sample size in the current study.

- *Comparative fit index (CFI)*

The CFI is an incremental fit index that is based on the non-centrality measure, degrees of freedom (Kenny, 2011:5). It is correlated with the TLI as they both decrease when the sample size is small and more variables are added, and thus either one can be reported at once (Zen, 2007). However, it is more appropriate in finite samples than the NFI, which behaves erratically in ML estimations. The value should be greater than or equal to 0.90 (Hu and Bentler, 1999; Zen, 2007). A value of 0.8 and above is acceptable (Abedi *et al.*, 2015).

- *Tucker-Lewis Index (TLI)*

The TLI depends on the average sizes of the correlations in the data, and violations of multivariate normality and is more reliable than the CFI and NFI, which decrease with more parsimony (Hu and Bentler, 1999; Zen, 2007; Kenny, 2011). Values greater than or equal to 0.90 indicate an acceptable fit and can be improved substantially; 0.8 is liberal or acceptable (Zen, 2007). However, the TLI is less preferable when the sample size is small as it tends to over-reject true-population models (Hu and Bentler, 1999:1).

- *Normed fit index (NFI)*

The NFI, also known as the Bentler-Bonnett normed fit index, may underestimate fit for smaller sample sizes, but generally it should be greater than or equal to 0.90 (Hooper *et al.*, 2008:55). A cut-off of 0.80 is liberal or acceptable (Abedi *et al.*, 2015). The NFI depends on sample size and would decrease when more variables are deleted. Thus, in the current study, with small sample size, and weak path coefficients deleted, NFI values of above 0.8 indicated an acceptable fit.

- *Parsimonious normed fit index (PNFI)*

The parsimonious fit index is the NFI adjusted based on the model's ability to fit data. It is generally insensitive to sample size, model misspecification and parameter estimates and thus could be a reliable indicator of model fit with smaller samples (Hooper *et al.*, 2008: 56). Although there is no commonly agreed-upon cut-off criteria, values within the 0.50 range are acceptable (Zen, 2007; Hooper *et al.*, 2008). However, the PNFI is best used when comparing non-nested models with the same data and requires sample of 200 for the values to be reliable. Hence, it was not used in the study.

Essentially, stringency in conforming to the prescribed cut-off criteria is untenable as opined by Marsh *et al.* (2004). Nonetheless, an adequate cut-off criterion should result in minimum Type I error (the probability of rejecting null hypothesis when it is true) and Type II error (the probability of accepting the null hypothesis when it is false) (Hu and Bentler, 1999:27; Musonda, 2012:127). The decision on model fit criteria was therefore made considering the two-index strategy advocated by Hu and Bentler (using absolute and comparative fit indices) (1999). Although a one-index approach could have been used, a two-index approach provided complimentary statistics to measure model fit. A two-index approach was used even though combinational rules had a tendency of rejecting true-populations models, for instance, the RMSEA and TLI, which are less preferable when the sample size is small ($N \leq 250$) (Hu and Bentler, 1999:28). However, a number of these indices were used in determining model fit and if majority indicated a good fit, then there was probably a good fit as advised by Schreiber *et al.* (2006:327).

Based on the above discourse, the range of criteria which were adopted in the current study were the absolute fit indices (CMIN/df, SRMR and RMSEA) as well as the comparative fit index (CFI) (Table 4.17). These were observed to be sufficient to explain model fit (Hu and Bentler, 1999; Schreiber *et al.*, 2006).

Model specification and modification

The model-generating approach to confirmatory factor analysis was employed (Byrne, 2001). This entailed modification to the measurement model in order to obtain the best-fitting model for structural modeling. An examination of the model estimates and fit indices revealed modifications were necessary to improve fit (Chinda and Mohamed, 2007:123). Model modifications (expansions or simplifications) based on variable effects are allowed to improve model fit, albeit with cognizance of other reasons which may affect model fit such as sample size, missing data, non-normality and outliers (Boomsma, 2000:475). However, since these were taken care of at the initial stage of analysis, modifications were believed to be appropriate. This was even more so with the adoption of the model generation approach for confirmatory factor analysis, as opposed to the strictly confirmatory or alternative model scenarios (Byrne, 2001:7).

Table 4.17: Cut-off criteria for fit indices used in the current study

Model fit indices		**Cut-off criteria**	**Source**
Comparative	Comparative fit index (CFI)	Close to 0.95 ≥ 0.90	Hu and Bentler (1999) Kline (2005) Schreiber *et al.* (2006) Zen (2007) Hooper *et al.* (2008)
Absolute	Relative chi-square (CMIN/DF)	χ^2 to df ≤ 2 or 3	Byrne (2001) Schreiber *et al.* (2006) Guo *et al.* (2009) Hooper *et al.* (2008)
	Standardised root mean square residual (SRMR)	> 0.05 to 0.08 The lower the better	Hu and Bentler (1999) Kline (2005) Schreiber *et al.* (2006) Hooper *et al.* (2008) Kenny (2011)
	Root mean square error of approximation (RMSEA)	Close to 0.06 0.05 – 0.07 – good fit 0.08 – reasonable fit > 0.10 – poor fit	Hu and Bentler (1999) Steiger (2007) Hooper *et al.* (2008)

The standardised residual covariance matrices after respective runs were checked for discrepancy and possible areas of misfit in the model. The standardised residuals are analogous to *z* scores, and are easier to interpret than unstandardised residual estimates. They represent estimates of the number of standard deviations that the observed variables are from the zero residuals which would exist if the model were a perfect fit with the data (Byrne, 2001:89).

Paths with weak standardised multiple squared correlation values R^2 (which showed the variance contributed by each variable) were deleted one by one. The model was rerun every time a path with low standardised coefficient and associated error variance term (represented as circles or ellipses with arrows to their respective indicators) was deleted. The deletion was done iteratively because changing one parameter triggered changes in others (Boomsma, 2000:475). Thus, arrows for items with low squared correlations were removed as they indicated very high levels of error. By deleting the items, parsimony was improved (Byrne, 2001:161). Although model parsimony (where no effect is constrained to 0 and will always fit the data, leading to Type 1 error) may be a problem, adding or removing paths tends to increase fit.

In addition, the modification indices (MI) were examined to check for redundant items which could be candidates for deletion or modification to improve model fit. The MI indicated the correlation between a pair of items in a measurement model. They showed a pair of items which were redundant or non-discriminant in a given model (Awang, 2012:67). Values greater than 15 for respective variables indicated redundancy and should be deleted (Awang, 2012).

Two options were considered for modification, including: i) deletion of the item with the lower factor loading between the two identified redundant items; and/or ii) by constraining the pair of redundant items as free parameter estimates (this was done by correlating the variables with the two-headed arrows) (Awang, 2012:62). The test was rerun to improve model fit.

Modification was done with regard to theoretical justifications or points of view established in the current study (Byrne, 2001:247). The emerging measurement sub-models were therefore used for structural modeling. The maximum likelihood estimates which were examined during the structural modeling were the standardised regression estimates in conjunction with the fit indices.

In sum, the steps which were taken to establish the best fitting model (measurement model) for structural equation modeling entailed the following:

- Running the analysis for the latent constructs in the sub-models (pooled measurement models) for the feasibility study quality, feasibility study elements, and project sustainability measures;
- Examining the fit indices obtained for the measurement model;
- Examining the residual matrix for possible areas of misfit and deleting items with high values; deleting items with high correlations (above 1.0) with many other items in the model as evinced from the standardised residuals covariance matrix;
- Deleting items with lowest factor loadings or variance explained in the model (squared multiple correlations below 0.5 were problematic items), one factor at a time;
- Running the new measurement model each time an item was deleted, bearing in mind that item deletion may not exceed 20% of the total number of items and latent constructs should have at least two or three items;
- Examining fit indices for the new measurement model;
- If fit indices were not achieved, checking the modification indices (MI) for items which may be redundant in the model and could be deleted or constrained as free parameters;
- Constraining the redundant or highly covaried items and adding a path, where necessary;
- Examining the fit indices of possible measurement models and selecting best fitting model; and
- Reporting the validity of the remaining constructs and selected measurement model.

The selected final measurement sub-models were further examined for statistical significance. This was necessary in order to make conclusions regarding the appropriateness of the model (Byrne, 2006). The factor loadings (regression weights), standard errors and critical ratio estimates were assessed in order to decipher if the model parameters were statistically significant (Musonda, 2012:179). For the parameters to be said to be statistically significant, the squared multiple correlation and the factor loading values should be less than 1.0. Values greater than 1.0 are unreasonable and statistically non-significant (Byrne, 2006). In addition, the critical ratio values, akin to *Z* statistic, which is the parameter estimate divided by its standard error, needed to be greater than 1.96 at the 0.05 significance level for it to be statistically different from zero and considered significant.

Structural model analysis

Following the running of the confirmatory factor analysis as described above, the structural model analysis was undertaken (Hu and Bentler, 1999; Boomsma, 2000; Byrne, 2001; Awang, 2012; Musonda, 2012). Essentially, for CFA, the reliability of the observed variables, given the squared multiple correlations, in relation to the latent constructs was the key information; whereas the factor loadings or regression weight (variance accounted for in the endogenous construct) was required in SEM (Schreiber *et al.*, 2006:327).

The hypotheses postulated were tested using the SEM, to show the impact significance of the variables theorised as predictors in the endogenous constructs. For the indirect relationships under investigation, bootstrapping was performed. This entailed creating a confidence interval to determine the mediation effect between feasibility study elements and project sustainability. Bootstrapping, being a nonparametric approach to statistical inference, was advocated when the data is not normally distributed, and confidence intervals were to be determined around the estimate of the mediated effect (Lockwood and MacKinnon, 1998:6). In addition, bootstrapping performs better than parametric procedures in small to moderate samples in terms of Type 1 error rates and statistical power (Hayes and Preacher, 2010:646). Further, when it is difficult or impossible to derive the standard error of a statistical index, resampling methods such as bootstrapping is advised (Hayes and Preacher, 2010:645). Because estimates of the standard error fluctuate widely, bootstrapping resamples the original sample multiple times, creating a normal distribution and forcing symmetric confidence intervals to derive more accurate estimates, as opposed to traditional methods (Hu and Wang, 2010; Kenny, 2018). Bootstrapping was therefore observed to be suitable in estimating standard errors and computing confidence intervals for mediation effect in the current study. Moreover, the bootstrap resampling method was selected because it was available in the AMOS software as opposed to other resampling tests such as the Sobel test, and the Monte-Carlo test (which was a parametric test and therefore less suitable).

To determine the confidence limits (upper and lower bound estimates), the bias-corrected percentile method of bootstrapping was applied, as opposed to other methods such as the bootstrap-*t* and bootstrap-*Q* methods (MacKinnon *et al.*, 2014). The bootstrap-*t* option is based on the *t* statistic rather than the indirect effect itself; while the bootstrap-Q transforms the t estimates (MacKinnon *et al.*, 2014). Percentile bootstrapping is used when avoiding Type I error is the main concern, while the bias-corrected percentile method is used when statistical power is the major concern (Kenny, 2018). Moreover, the bias corrected approach was necessary in order to give reliable estimates since bootstrapping tends to inflate values. It therefore allowed for true values to be displayed below and above intervals. A confidence interval of 95% (significance at the 0.05 level) was set. For a 95% confidence interval, the lower limit was at the 2.5 percentile and the upper limit was at the 97.5 percentile (Lockwood and MacKinnon, 1998:2). The number of bootstrap samples was set at 500 as suggested by Hu and Wang (2010).

For the null hypotheses to be rejected, the indirect effect had to be significantly different from zero. Lower bound and upper bound limits were generated in the procedure in AMOS, and *p* values were displayed. The results were checked if zero fell between or outside the lower and upper bound intervals. If zero was not in the interval, then the indirect effect was significantly different from zero and the null hypotheses may not be rejected (Kenny, 2018). In other words, if zero fell outside the lower and upper bound values, then there was significant indirect mediating effect and the null hypotheses may be rejected.

The structural equation modelling process, which entailed measurement model estimation and structural model analysis, is presented in Figure 4.2. The findings from the hypotheses testing were thereafter discussed and integrated with extant literature in relation to the study objectives.

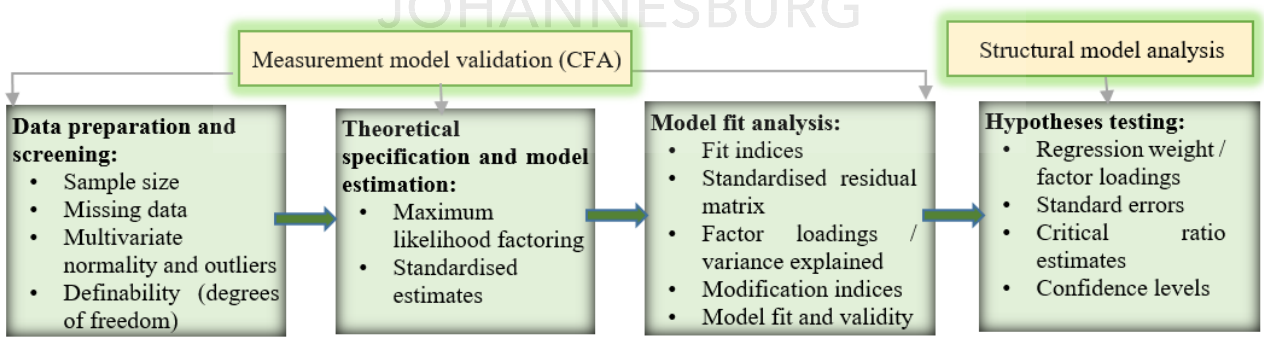


Figure 4.2: Structural equation modeling procedure

4.6 RESEARCH QUALITY - VALIDITY AND RELIABILITY

The validity and reliability of the research findings were important considerations while conducting the study. Validity in research means appropriateness of the tools, processes and data, the choice of research methods in answering the research question, the sampling, and data analysis and the results and conclusions (Leung, 2015). The choice of methods must enable the detection of findings in the appropriate context. Reliability on the other hand, refers to the extent to which a research instrument yields the same result on repeated trials (Alshenqeeti, 2014:44). Issues of validity and reliability of findings from both the multi-case study and questionnaire survey phases were therefore attended to in order to enhance the quality of the current research. Hence, the quality of the empirical research phases was enhanced and assured based on different criteria, as supported in extant literature and discussed hereunder (Table 4.18) (Krefting, 1991:217; Stewart, 2012; Yilmaz, 2013).

Table 4.18: Validity and reliability criteria in qualitative and quantitative terms

Aspect	Qualitative	Quantitative
Truth value	Credibility	Internal or content validity
Applicability	Transferability	External validity or generalisability
Consistency	Dependability	Reliability
Neutrality	Confirmability	Objectivity

Sources: Stewart (2012) and Yilmaz (2013:320)

4.6.1 Validity and reliability of the multi-case study research

For the multi-case study phase of the research, validity and reliability considerations included convincingness, credibility, transferability, fittingness, auditability, dependability, confirmability; while for quantitative research, the issues were internal and external validity, reliability and objectivity. Truth value is concerned with confidence in the truth of findings based on the research design, informants and context. Applicability or transferability refers to the extent to which findings may be generalised or transferred to similar contexts. Consistency is related to whether the findings can be replicated to produce the similar results; while neutrality relayed freedom from bias in the research procedures and results (Krefting, 1991).

4.6.1.1 Credibility

Credibility was enhanced by the extent to which the researcher used techniques of producing trustworthy data. These included systematic data collection procedures, multiple data sources, triangulation, member-checking, and peer debriefing, as captured by Yilmaz (2013). Credibility has to do with the confidence that can be placed in the data (sources) or whether the information drawn from participants are correctly interpreted (Anney, 2014:276). Therefore, during the document analysis, effort was made to obtain the required information from the actual feasibility reports conducted on the identified cases. The cases were identified from relevant sources, which were observed to be custodians of the feasibility reports. Obtaining the specifically required information from the relevant sources helped to improve the convincingness (validity of case research) of the study, given that such information could only be obtained from the entities themselves (Stewart, 2012). By selecting feasibility studies conducted on particular transport projects and prepared by individuals who are knowledgeable in the subject being investigated, the study included documents which were credible (trustworthy and prepared with expertise), authentic (genuine evidence), meaningful and representative of documents pertaining to the subject under investigation (Ahmed, 2010:3).

Expert or professional content reviews of interview schedules as well as peer debriefing (involving another researcher to review the findings as reported to see if it resonates with the experience of the participants and the audience rather than the researcher's) were employed to ensure accuracy of the account and thus credibility of the findings (Yilmaz, 2013:321). Further, respondent verification or member checks after the interviews also enhanced validity of findings (Leung, 2015). Follow-up interviews were conducted telephonically with some of the interview respondents to adequately capture their viewpoints (Yilmaz, 2013:321).

4.6.1.2 Transferability

The explicit and rich description of the research processes, contexts, techniques and assumptions ensured transferability or applicability of the findings to other similar contexts or setting, as Lincoln and Guba (1985) suggested. Transferability, which is concerned with the degree to which evidence and findings of the research can be applicable to other contexts, times, situations and populations was thus achieved by the detailed descriptions of the contexts and participants. In other words, it implies the extent to which the results can be generalised to other contexts. In the multi-case study, transferability was achieved by the inclusion of projects of a diverse nature, as well as participants from different entities, including private and public. Therefore, generalisability was enhanced (Green, 2008).

4.6.1.3 Dependability

Similarly, dependability, which is concerned with whether the same results can be obtained in a repeated study, was also achieved by providing rich descriptions of the context, settings and participants and unit of analysis (projects) in the multi-case study phase (Social Research Methods, 2013). In addition, by including different projects from various organisation, different experiences were captured and thus increasing variability of contexts and consistency of findings (Krefting, 1991:216).

Triangulation of data sources using document analysis and interviews to complement and corroborate evidence also enhanced dependability (Krefting, 1991:217; Anney, 2014:277). The data triangulation method, which measures the same variables with different techniques to ensure accuracy and valid convergence of findings, was therefore used to improve the validity of the results (Johnson *et al.*, 2007:114; Schiazza, 2013).

Additionally, the code-recode strategy, whereby the researcher coded the same data twice, in order to compare the results and gain a better understanding of data patterns, and thus enhancing dependability of the qualitative inquiry (Anney, 2014:278).

4.6.1.4 Confirmability

Confirmability of the multi-case study findings, which has to do with the degree to which the results could be confirmed or corroborated by others, was ensured in the current study. As stated earlier, member checks and peer audit briefing ensured confirmability for the results and reduced the degree of potential bias in the findings (Social Research Methods, 2013). In addition, auditing of the data collection and analysis techniques was done by a qualitative research expert who followed through the process and progress of events to understand and review how and why certain decisions were made. The auditor considered the whole process of the qualitative research, as well as the data, interpretations, thematic classifications, inferences, and recommendations (Anney, 2014:278). The code-recode strategy also helped to verify and check that errors were corrected during the theory development, and the improving confirmability (Morse *et al.*, 2002:17).

4.6.2 Validity of the quantitative research

4.6.2.1 Test content or internal validity

Test content or internal validity refers to the extent to which a scale's items, in the aggregate, constitute a representative sample of the topic's content domain (Ro *et al.*, 2015). Expert review and validation of the questionnaire by the research supervisors and statistician enhanced face and test content validity of the research tool (Ro *et al.*, 2015). The questionnaire was reviewed and further revised after a pilot study among potential respondents who were purposively selected. The validation and expert review of the research instrument served to make the questions clear and unambiguous and ensure that the scales reflected what they were supposed to measure (Anney, 2014:275).

4.6.2.2 External validity

External validity, which refers to how well the results of a study can be generalised across populations, settings and time, was achieved in the current study by including respondents from multiple organisations and projects (Tayie, 2005:27). Including participants from different provinces who have worked on different transport projects served to enhance external validity (good generalisability) (Trochim, 2006). In addition, including projects of a varied nature including roads, rail, bridges, airports, tunnel and transport services, from the different organisations, improved the generalisability and thus external validity of the study findings (Yun and Caldas, 2009).

Statistically, construct validity was achieved through the application of factor analytic techniques (specifically, principal components analysis) to empirical data that were obtained from the field questionnaire survey to determine whether a factor represents the construct which it is intended to measure and does not represent others that are theoretically different, thereby establishing discriminant or convergent validity (Trochim, 2006). The results of the factor analysis are presented in a later section.

4.6.3 Reliability of the quantitative research

Internal consistency reliability of the scales used in the questionnaire was statistically assessed using the Cronbach's alpha coefficient α and mean inter-item correlations before and after the EFA. These indices gave an estimate of how well the items that reflect the same construct yield similar results or how consistent the results are for different items for the same construct within the measure (Trochim, 2006). However, mean inter-item correlations are mostly reported when low Cronbach's alpha values are obtained (as a result of small number of items in a subscale (Pallant, 2013:104).

Cronbach's alpha coefficient α and mean inter-item correlations represent average correlations among items and are used when questions are rated on internal scales such as five-point Likert scales (Pallant, 2013:101). The Cronbach's alpha coefficients present the level at which the measurement is error-free and therefore presents consistent results. The reliability of each of the sub-scales as well as the total scale (for feasibility study elements and project sustainability subscales) were calculated, because some subscales may not be combined to form a total score (Pallant, 2013: ibid.). Cronbach's alpha values range from 0 to 1, with 0.7 (some say 0.6) indicating acceptable reliability and 0.8 or higher indicating good reliability (Zaiontz, 2014). Values above 0.7 are considered acceptable, while values above 0.8 are preferable (Pallant, 2013:104). Other descriptions of alpha values have been proffered. These include excellent (0.93 – 0.94), strong (0.91-0.93), reliable (0.84-0.90), robust (0.81), fairly high (0.76-0.95), high (0.73-0.95), good (0.71-0.91), relatively high (0.70-0.77), slightly low (0.68), reasonable (0.67-0.87), adequate (0.64-0.85), moderate (0.61-0.65), satisfactory (0.58-0.97), acceptable (0.45-0.98), sufficient (0.45-0.96), not satisfactory (0.40-0.55) and low (0.11) (Taber, 2017:7). Mean inter-item correlations should range from 0.2 to 0.4 (Pallant, 2013:101). However, higher values indicate stronger relationships among the items.

Table 4.19 presents the results from the Cronbach alpha testing of the questionnaire's sub-scales before further statistical testing was undertaken. The Cronbach's alpha values for the three-item structure of feasibility study factors ranged from 0.72 to 0.93, indicating high reliability. The values for the feasibility study quality sub-scales were 0.73 and 0.84, for *people* and *procedures*, respectively, and thus indicating strong reliability. The six-item structure of project sustainability measures ranged from 0.76 to 0.84, indicating good reliability. Thus, the Cronbach's alpha values of the sub-scales in the theoretical framework ranged from 0.72 to 0.93, indicating good internal consistency (Zaiontz, 2014). With regard to the inter-item correlations, values ranged from 0.25 to 0.64, indicating good reliability.

Table 4.19: Cronbach's alpha test results before EFA (theoretical framework)

Construct		Cronbach's alpha	Mean inter-item correlation	Number of items
Transportation infrastructure feasibility study (TIFS)	Data used	0.72	0.25	8
	Criteria factors considered	0.93	0.39	21
	Methods used	0.89	0.51	9
Feasibility study quality (FQ)	People	0.73	0.34	5
	Procedure	0.84	0.52	5
Project sustainability	Socio-economic factors	0.84	0.40	8
	Financial factors	0.84	0.64	3
	Condition of infrastructure	0.84	0.57	4
	Safety and security	0.76	0.38	5
	Stakeholder satisfaction	0.83	0.50	5
	Service quality	0.78	0.54	3

4.6.3.1 Internal consistency reliability of the EFA sub-scales

The internal consistency reliability coefficient in the EFA sub-scales established that the structures were reliable measures of feasibility study factors (TIFS), feasibility study quality (FQ) and project sustainability (PS) (Table 4.20). The Cronbach's alpha index for the sub-scales after EFA were 0.92, 0.86 and 0.92 for TIFS, FQ and PS, respectively.

Table 4.20: Cronbach's alpha test results before and after EFA

Constructs	Cronbach's alpha before EFA	Cronbach's alpha after EFA
TIFS measures	0.94 (N = 38)	0.92 (N = 23)
FQ measures	0.88 (N = 10)	0.86 (N = 7)
PS measures	0.95 (N = 28)	0.92 (N = 14)

4.6.3.2 Convergent and discriminant validity of the empirical constructs after EFA

The convergent validity of the EFA sub-scales were determined from the EFA, based on the pattern matrix loading results. The EFA established items loading on a single factor as expected with cross-loadings thereby establishing discriminant validity. Hence, construct factorial validity was established. This was necessary before further analysis using confirmatory factor analysis, which is conducted with fully developed assessment measures that have demonstrated factorial validity (Byrne, 2001:121).

4.6.3.3 Reliability and validity of the SEM results

Ultimately, the measurement model should be assessed for unidimensionality, reliability and validity prior to modeling the structural model. Unidimentionality requires that all factor loadings should be positive and above 0.5 for newly developed items and 0.6 or higher for established items (Awang, 2012:54). Unidimensionality was attained through the item-deletion procedure for low factor loading items. The selected measurement models had all the factor-loadings above the recommended 0.4 and were positive values. The results are presented in a later section.

The reliability and validity of the measurement models were also assessed using model fit indices, composite reliability and average variance extracted statistics as suggested by Awang (2012) and Tutors (2015).

Composite reliability (CR) - The CR indicates the reliability and internal consistency of a latent construct. It measures the confidence level of latent variables in the established confirmatory factor model considering measurement variables' factor loadings and error variances, (Xue *et al.*, 2018). The CR for each construct was calculated using the formular:

$$CR = \frac{(\Sigma\lambda_j)^2}{[(\Sigma\lambda_j)^2 + \Sigma(1-\lambda_j^2)]}$$ **Equation 4.3**

where λ is the factor loading (standardised regression weights) (Jayasinghe-Mudalige, 2012:21). A value of CR > 0.6 or 0.7 is needed to achieve composite reliability for a particular construct (Awang, 2012; Jayasinghe-Mudalige *et al.*, 2012: 21; Ahmad *et al.*, 2016:3; Xue *et al.*, 2018).

Average Variance Extracted (AVE) - The AVE statistic indicated the average percentage of variance explained by the measuring items for a latent construct. It was calculated using the formular*:*

$$AVE = \frac{\Sigma\lambda_i^2}{n}$$ **Equation 4.4**

where λ is the factor loading and *n* is the number of items in the construct. An AVE > 0.5 is required for the respective constructs to achieve reliability (Awang, 2012; Jayasinghe-Mudalige *et al.*, 2012:21; Ahmad *et al.*, 2016:3; Xue *et al.*, 2018).

Convergent validity - The AVE test is a convergence validity indicator as it evaluates the variances of measurement variables that can be explained by latent variables with a discriminating standard of larger than 0.5 (Xue *et al.*, 2018). In other words, convergent validity was achieved during CFA in this study with all the AVE values exceeding 0.50 (Awang, 2012:69).

Construct validity **–** The model fit indices, which met the required levels, indicated that the model was reliable (Marsh *et al.*, 2004).

Discriminant validity - When all the redundant items in the model were either deleted or constrained as "free parameters", discriminant validity was reached (Awang, 2012). The modification indices results indicated pairs of items, which were redundant or covarying highly with each other, having values greater than 15, resulting in poor model fit. In addition, when the square root of the AVE was greater than the inter-construct correlations, then discriminant validity was achieved (Ahmad *et al.*, 2016:3). In other words, the inter-construct correlations were not high and thus discriminant validity was achieved (Musonda, 2012:129). The inter-construct correlations should not be greater than 0.85 (Ahmad *et al.*, 2016:3). A value of 1.0 indicates that the constructs are measuring the same thing and thus non-discriminant (Hooper, 2008:56).

Therefore, the measurement models for the feasibility study quality, feasibility study elements and project sustainability sub-models were considered reliable and valid based on the criteria described above and summarised in Table 4.21.

Table 4.21: Criteria and cut-off values for CFA measurement models

	Criteria	**Cut-off value / condition**
Reliability	Composite reliability (CR)	Should exceed 0.7 Should exceed 0.6
	Average Variance Extracted (AVE)	Should exceed 0.5
Validity	Convergent validity	All values of AVE exceed 0.50.
	Construct Validity	Model fit indices should meet the required cut-off values
	Discriminant or divergent validity	Modification indices should not exceed 15; the square root of the AVE should be greater than the inter-construct correlations; inter-construct correlations should be less than or equal to 0.85

Sources: Awang (2012), Jayasinghe-Mudalige *et al.* (2012), Ahmad *et al.* (2016) and Xue *et al.* (2018).

4.7 ETHICS

The study was approved by the university's Ethics Committee. Attention was paid to integrity and ethical conduct during the study. Issues regarding the purpose of the study, terms of confidentiality (including a non-disclosure agreement, which was signed for one of the projects), length and format of interview, mode of contacting the researcher as well as recording of information were clarified before the interviews commenced (Turner, 2010). In addition, the following were explicitly considered and done in order to ensure ethical conduct:

- Autonomy - The participants were interviewed and surveyed about the processes, methods, systems and data employed to conduct the feasibility studies. Although the participants were not the unit of measure or analysis, they were informed of their right to participate in the study, or withdraw after consent had been given. Informed consent in writing was sought and obtained from the company directors on behalf of some of the participants. The participants were given time and opportunity as well as adequate information that they needed to decide whether to take part or not. They took part voluntarily. They were not unduly influenced, induced, forced or coerced in any way to participate. Additionally, each participant's consent to audio-record the interview was sought before commencement with audio-recording during the interviews. Further, consent was obtained to quote respondents in future and resulting publications from the study (Grinyer, 2009).
- Beneficence – Consideration was made with regard to the possibility that the researcher would be privy to sensitive information during document analysis. Therefore, the participants were informed that the results from the study were to be used for academic research purposes only. Since transportation infrastructure projects are vital to the socio-economic development of the economy, the research was important and this was communicated.
- Non-maleficence - The possible risk to participants of the disclosure of sensitive and confidential information to the public was also contemplated. Consent to access such information was obtained from the Heads and Director at the entities surveyed, after formal introduction and furnishing of Ethics approval from the university for the study. The researcher was also required to sign a non-disclosure agreement at one of the entities before research commenced.

- Justice - The participants were included based on their experience and involvement in the feasibility studies and/or management and operations of the selected transportation infrastructure projects, as well as their willingness to participate without undue influence.

Therefore, ethical considerations were of paramount importance during this research.

4.8 CHAPTER SUMMARY

The current chapter presented a discourse on the techniques and procedures that were adopted to collect and analyse data for the study. After a detailed literature review, feasibility study and performance variables were identified. Multi-case studies were then undertaken using interviews and document analysis of feasibility and performance/progress reports. Representative samples which can validly apply across transportation infrastructure projects were recruited in the current study.

Cases (projects) which had been in operation for at least one year were included. In addition, projects were included if they had sufficient information and reliable analysis could be made based on their contextual attributes. For data extraction and analysis, several methods were adopted to enhance validity, including triangulation of data collection methods including the use of document analysis, interviews and case-oriented multi-dimensional analysis, as well as questionnaire survey.

Interviews were conducted with professionals who had worked or were currently working on the case study projects, to identify factors, which may not have been revealed from the literature review, as well as to develop the conceptual framework based on the theorised factors. Document analysis was also undertaken to triangulate findings from the interviews or verbal reports of the participants. By collecting data from multiple sources and uncovering multiple understandings of the relationship between the performance of transport projects and the quality of feasibility studies, triangulation, credibility of findings, was attained.

Findings from the interviews and document analysis were analysed with the aid of Atlas-ti software version 7 to identify themes and categories emerging from the contextual data, as well as potential relations between the variables. A conceptual framework was formed based on the qualitative findings. Hypotheses were thereafter postulated, based on the conceptual framework, for testing and validation of qualitative findings.

Quantitative data was collected by means of a questionnaire distributed among built environment professionals, consultants, managers, environmental specialists, and planners. The data were analysed using SPSS Statistics version 25 and SPSS AMOS version 25. Common factor analysis was conducted on the conceptual constructs and variables to examine their structures and further refine them into manageable constructs for ease of further testing. Outputs from the factor analysis were "common factors". The common factors were believed to account for most of the variance in the observed variables. These were rotated and interpreted to determine the items which defined them. The reduced measures were then loaded unto the AMOS software version 25 in order to establish a measurement model, prior to testing the structural model. The SEM subsequently established the relationships between and among variables and latent constructs.

Issues of reliability and validity were also discussed in this chapter. All the sub-scales in the conceptualised model had good internal consistency. Validity was improved by refining the framework using triangulating sources (document analysis and interviews), expert reviews of questionnaire, purposively selected transport projects and participants in different entities, descriptions of the cases within case and across cases, as well as reviewing and resolving disconfirming evidence with member checks. Reliability and validity of the empirical frameworks were also established using statistical tests including the Cronbach's alpha coefficient, and evinced from the discriminant factorial structure of the EFA and CFA.

The succeeding chapter presents the results from the qualitative phase. Additionally, the conceptual framework which was further refined with integration of findings from the literature review, was discussed.

CHAPTER FIVE

FINDINGS FROM QUALITATIVE RESEARCH

5.1 INTRODUCTION

The findings from the qualitative multi-case study phase are presented in this chapter. Details on the background of the cases (projects) and the findings regarding how feasibility studies were conducted and how the projects performed, are presented. In addition to reporting the findings from each case studied, the respective cases are discussed comparatively (across-case analysis) in order to highlight the commonalities and differences between and among the projects with regard to the concepts under study.

Therefore, this section outlines the feasibility study structures, processes and methods, reference data as well as criteria factors incorporated in feasibility studies; and the performance of transportation projects as established from ten projects, first in respective cases and then across cases. Reference was also made to existing literature in discussion. Lastly, the chapter concludes with a summary of key findings and suggestions gathered from the cases through the interviews. The findings as they were analysed through template coding to output themes on feasibility study elements and project sustainable performance are presented in Appendix VI.

5.2 LOCATION OF THE PROJECTS

The projects which were studied in the current research are located in one of South Arica's nine provinces, Gauteng. Gauteng, the place of gold, is the economic powerhouse of the South African economy (GMA, 2011:2). The province is made up of three metropolitan municipalities: Johannesburg, Tshwane and Ekurhuleni. The province covers less than 2% of the country's surface area, with a population of 14.6 million (in 2015). Gauteng has the most developed infrastructure in Africa but has a traffic congestion growth of 7% per annum and the current infrastructure is unable to sustain projected increases (GMA, 2011:58; Andrew and Thoms, 2015:42). Because of the vital role that Gauteng plays in the national economy, contributing 36% of the country's GDP, the province was partly chosen for the current study (Andrew and Thoms, 2015). The province was also partly chosen because it was convenient for the researcher.

5.3 DESCRIPTION OF THE PROJECTS

5.3.1 Case study 1 - The City Deep freight hub

The City Deep hub consists of six projects within the area outlined by the M2 motorway in the north, the N17 in the south, the N3 in the east and Wemmer Pan Road/Rosettenville Road in the West (Arcus-Gibb, 2010). The aim of the city deep projects was to increase capacity of the existing networks in the area.

Three of the six projects were completed in early 2016 and therefore were included in the current study. These projects included upgrading and expansion of the roads. The three operational projects' contract amount was R9, 499, 875 (total project cost for the six is R121, 942, 275).

The projects were executed based on an agreement between the Gauteng Province Department of Roads and Transport, the Johannesburg Roads Agency (JRA) and the South African National Roads Agency Limited (SANRAL). The agreement clearly stated the party responsible for implementation, administration as well as management of the projects.

The feasibility study for the project was conducted in 2010. The project had been in operation for two years and was therefore included in the current study because it had sufficient and stable performance data.

5.3.2 Case study 2 – The Gautrain

The Gautrain project, the first rapid rail transport system in Gauteng, has two corridors, namely: the South-North and West-East. The South-North route starts from Park station precinct in central Johannesburg to Rosebank Station and onwards to Hatfield. The West-East route starts from Sandton station via Marlboro, to Rhodesfield station in Kempton Park and then connects at the OR Tambo International Airport (Figure 5.1) (GMA 2011:68).

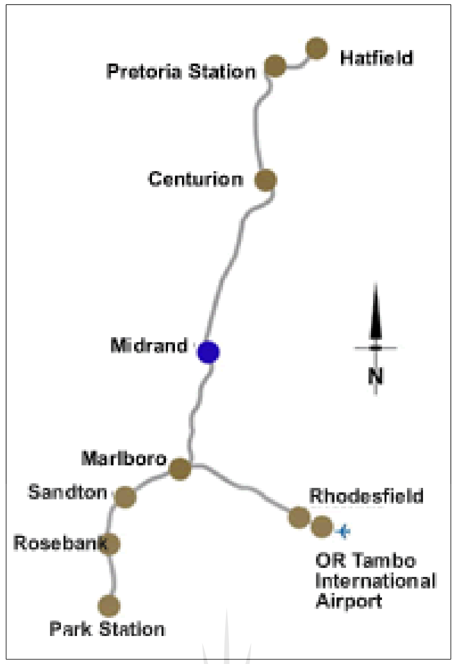


Figure 5.1: The Gautrain route (Andrew and Thoms, 2012:43)

The primary aim of the project was to ease severe traffic congestion between Johannesburg and Tshwane/Pretoria and between Sandton and OR Tambo International Airport, by promoting public transport as an alternative to private vehicle usage (among car users) (GMA, 2012;2015). Promoting public transport is one of the requirements reflected in the National Land Transport Transition Act 2000 (Andrew and Thoms, 2015:42). Stimulation of economic growth in Gauteng through enhancing infrastructure development and creating employment was a further objective of the Gautrain project (GMA, 2012; 2015).

The project is a partnership between the three levels of government, with parastatals and private consortia. As such, it has a myriad of stakeholders, with a PPP (Build-Operate, Maintain and Transfer) concession up until 2026, granting rights, and setting out concomitant obligations, to design, build, partly finance, and operates the system for 19 and half years (GPDRT Annual Report, 2013:50; GMA, 2016). The contract amount, signed in 2006, was R7 billion. However, the project amount at completion was approximately R30 billion. The project includes the train set as well as the feeder and distribution system to the stations. The feeder and distribution system was provided by the concessionaire as part of an integrated service, together with the train service (GMA, 2011:69).

The feasibility study (including the pre-feasibility) was initiated in 1999. It was conducted in two parts, first by the government and then by the concessionaire. Construction was done in two phases and so operations started first in June 2010 (phase 1, for the Soccer World Cup) and then in 2011 (phase 2). Therefore, the project has been in operation for about eight years.

The Gautrain project was therefore partially selected in the current study because it had been in operation for more than two years and therefore mature for data collection.

5.3.3 Case study 3 – The N12 (P186/1)

The N12 (P186/1) project is a road located south of Johannesburg, between Gauteng and North West Province. The objective of the project was to increase the capacity of the road network, which serves as a major collector/distributor for the urban areas along the route and southwest of Johannesburg (GPDRT Annual Report, 2015). The project entailed rehabilitation of approximately 9.54 km on road P186/1 (N12).

The project was publicly funded from the National Treasury at a total project cost of R120 million, including engineers consulting fees. The feasibility study was undertaken in 2012. The N12 project was included in the current study because it was observed to have sufficient performance information to be used in the current study.

5.3.4 Case study 4 – The D1027 (Cedar Road)

The Cedar road intersects with Valley Road at the Broadacres shopping centre in Fourways, in Region A of the City of Johannesburg Metropolitan Municipality. A section of the Cedar road was rehabilitated as part of the Steyn City development, between Valley Road and Runnymead road. The project involved the widening of the Cedar road on both sides to a double carriageway, consisting of new pavement layers, as well as rehabilitation of the existing road, which had extensive cracking that allowed rain to penetrate the base and subbase layers. Development of potholes and cracks rendered the network prone to evident failure and thus required rehabilitation. The project's main objective was therefore to improve the traffic capacity and pavement integrity of Cedar road so that it will last longer for a period of 20 years.

The project was undertaken with funding supported by a private partner, who contributed 30% of the contract amount (R96,148,800.00). Therefore, the GPDRT's input was 70% of the contract amount. The private partner was involved because the rehabilitation partly included the subject development (Steyn City). The partner offered us 30% to accommodate that development.

The feasibility studies were conducted in 2012 and the project has been operational for two years. Thus, the project was partially selected because it had mature data available for collection, having been in operation for at least two years.

5.3.5 Case study 5 – The K46

The K46 project is a single carriageway upgraded to an urban dual carriageway with 3.7m lanes in both directions within a 62m road reserve. Road K46 is an existing single East – West carriageway road commencing in the vicinity of Fourways ending in Diepsloot (near N14). It is between PWV5 and Diepsloot/N14. The road had to be redesigned to increase flow of traffic and make provision for a dedicated bus lane. The K46 (William Nicol) road was upgraded from a single to a dual carriageway including 1.5m cycle lanes and 1.5m pedestrian sidewalks, promoting the concept of non-motorised transport. It was completed at a cost of R576 million, in partnership with the GPDRT and the private sector, Steyn City, who had an agreement to deliver key infrastructure from which both will benefit (GPDRT Annual Report, 2015; News24, 2016).

The construction of the road was undertaken to improve access to the Diepsloot area and Fourways towards Randburg and ensure accessibility to the Monte Casino, Indaba Hotel and the Fourways shopping mall. The road project was implemented in phases. The feasibility study for Phase 1 was undertaken in 2011 and construction was completed in 2015. The second phase began in 2015 and was completed in January 2018.

The K46 project was included in the current study based on the feasibility conducted for Phase 1 and the on-going performance or progress of the road, which forms a very important link between the N14 and N1 south. The project was also included because there was rich data available in the feasibility reports. In addition, the objectives for which the project was expanded, was to improve accessibility and travelling time, ensure safety of users and upgrade road furniture and drainage systems, are being achieved at present.

5.3.6 Case study 6 – The BRTS

The Bus Rapid Transit (BRT) is one of the initiatives of the Department of Transport's (DoT) plan to implement high quality Integrated Rapid Public Transport Networks (IRPTNs) in 12 cities. The concept of the BRT was explored after an exposition at a South African Transport Conference in 2006, through a video from Brazil, showing the potential to alleviate public transport problems of accessibility, affordability and efficiency (Goondiwala, 2014). It was also believed to be implementable in a short time frame. The DoT's plan was thus initiated and approved in 2007 in the Public Transport Strategy (2007-2020) and Action Plan (City of Tshwane (CoT), 2016). Financing for the BRT system came from the National Treasury's Public Transport Infrastructure Systems (PTIS) Grant Funding (CoT, 2016).

The overarching vision of the Public Transport Strategy was to implement a continuous upgrading of the current public transport service to an upgraded modal service and then an integrated rapid transport network, which will maximise accessibility (including for the disabled) and promote non-motorised traveling (Pillay and Seedat, 2007). The IRPTNs were also planned to integrate with existing modes of transport (metered taxis, mini-buses, etc.), promote greater social cohesion and provide alternatives for maximum interconnectivity (Pillay and Seedat, 2007; Department of Transport, 2008). The whole BRT system is unique, having state of the art stations, automatic fare mechanism, dedicated and exclusive roadways and technical aspects of a centralised rail-based mass transit system (Goondiwala, 2014).

There are three BRTs in Gauteng (in Tshwane, Ekurhuleni and Johannesburg), built at a cost of approximately R10 billion (Venter, 2017). The BRT in Johannesburg, *Rea Vaya*, which links main nodes - the universities, the hospitals, stations, major shopping malls and so on, had an additional objective: to meet the obligations of hosting the 2010 Soccer World Cup.

The BRT in Tshwane (Pretoria), formally known as *A Re Yeng*, network integrates with the rail network at five key railway stations, including Kopanong, Wonderboom, Pretoria Station, Hatfield as well as Denneboom. This provides service linking industrial communities of Rosslyn, Hermanstad and Waltloo to commercial and business nodes such as Menlyn, Hatfield, Akasia, Montana as well as the Pretoria CBD. The integration and access to key land uses, such as Pretoria Zoo, University of Pretoria, Tshwane University of Technology (TUT – Town Campus), Menlyn Park Shopping Centre, Church Square, and Steve Biko Academic Hospital is supported by the network design. Access to these nodes is also intended to provide the system with balanced demand in terms of peak and off-peak variance and to provide alternative to car usage.

The current study conveniently included the BRT systems in Johannesburg and Tshwane as participants were available and willing to participate. In addition, sufficient data was availed to the researcher. The BRT project in Johannesburg and Tshwane were also partly included because they had been operational long enough to have stable and reliable performance data, being implemented more than five years ago.

5.3.7 Case study 7 – Tolwane Bridge 5610

The Tolwane Bridge 5610 is located on road D603 at km 3.6 close to Mapobane within the Tshwane regional district. Road D603 and Structure IDC2673 is located downstream of the Nooitgedacht Dam, across the Sandspruit, in Mabopane. The area was prone to flooding and had experienced flood damage twice during 2011 to 2015 (GPDRT Bridge Report, 2015). The bridge 5610 crosses the Tolwane River. In 2014, the approach roads and part of the bridge were eroded. Thus, the bridge was under-capacitated and required rehabilitation.

The feasibility studies were undertaken in 2015 to assess environmental, climatic and structural conditions and alternatives. The total contract amount was R 25,521,169. The project has just been completed but was however, included in the current study because of its unique characteristics. It was also partly included because the availed feasibility reports provided rich data, which was observed to be important, with valuable unique insights to the study.

5.3.8 Case study 8 – The K57 (R82) (Phase 1)

The K57 is located between D1073 and Road D77 in Walkerville within the Midvaal Local Municipality of the Gauteng Province. The road forms an alternative route to the Gauteng Freeway Improvement Project and is a single carriageway, which deteriorated over the years due to increased traffic (GPDRT Annual Report, 2014b:13). The project was being rehabilitated in phases. Phase 1, which was completed in 2013, involved the construction of 5.5 km of road between D77 and D1073, upgrading of the existing single carriageway into asphalt surfaced dual carriageway, upgrading of drainage (stormwater and sub-soil) (GPDRT Annual Report, 2014b). In Phase 2, the scope entailed the rehabilitation of the dual carriageway and construction of a four-lane dual carriageway that provides long eastern bypass to the residential township of Walkerville.

The project involved the construction of new culverts including a bridge at km 11.73; construction of three half intersections, 17 taxi lay-byes, and surfacing. The objectives of the project were to increase capacity, improve geometric standards and road safety, and improve accessibility to Johannesburg, Vereeniging and bordering farms (Polity, 2016). The projects were publicly funded and undertaken by the GPDRT as part of their mandate in provision of road infrastructure.

The above selected projects and their characteristics as discussed are summarised in Table 5.1.

5.4 FINDINGS ON PROJECT FEASIBILITY STUDIES

5.4.1 Case-by-case analysis: Project feasibility studies

This section presents the analysis of each project under the different classifications which emerged from the qualitative phase of the study with regard to the feasibility studies undertaken. The volume of data amassed during the qualitative research led to the coding of the findings according to the themes emerging from the data analysis. The findings on the feasibility studies are presented in terms of the structures, processes and methods, reference data and criteria factors considered on each project.

5.4.1.1 Case study 1 – The City Deep freight hub

Who was involved?

The feasibility study for the City Deep Hub was conducted in 2010. The feasibility study was conducted by engineering consultants, who were appointed by the main contractor (contracted by the GPDRT for construction). The engineering consultants undertook the feasibility studies (called transportation study) for the projects. Strategic advisors from the client (provincial government) were involved to audit the feasibility study outcomes.

Table 5.1: Profile of case study projects

Case	Project	Project characteristics						
		Project type	**Description**	**FS timeline**	**Procurement/ financing structure**	**No. of private partners**	**Project amount**	**No. of years in operation**
1	City Deep freight hub	Roads	Upgraded projects (3 out of 7 completed)	2010	Public	Nil	Approx. R122 million	2
2	Gautrain	Rail	New	1998-2001	PPP (BOT)	1	Approx. R30 billion	7
3	N12 (P186/1)	Road	Reconstruction of base and rehabilitation of 3 intersections along the road to N12	2012	Public	Nil	R120 million	4
4	D1027 (Cedar Road)	Road	Upgrade (widening to double carriageway) and rehabilitation	2012	Partnership (70% GPDRT; 30% private developer)	1	R96 million	2
5	K46	Road	Rehabilitation; upgrade from single to dual carriageway	2011	Partnership with developer	1	R576 million	2
6	BRTS	Rapid transit networks	New	Project initiated in 2007	PPP (Public-sponsored; private operator)	1	R10 billion	8
7	Tolwane Bridge	Bridge	Rehabilitation	2015	Public	Nil	R25,521,169	-
8	K57 (Phase 1)	Road	Rehabilitation/Revamp	2010	Public	Nil	R164,616,508	5

Processes and Methods

Detailed analysis was required to determine the impact of traffic growth on the capacity of the development. Scenarios (alternatives) were developed and analysed in terms of projected traffic growth and capacity after a certain number of years, say 5 years, 10 years and so on. The traffic data used included traffic counts as well as generated traffic from nearby developments (Arcus-Gibb, 2010). This was supported by the respondent:

"Yes, traffic counts…they select points around the area of interest…they count human beings…they sit and count how many vehicles and types. There are electronic tools used."

In addition, CBA was employed. Based on the traffic data and cost analysis (including contingencies), the alternative scenarios for development were chosen for delivery, as suggested by the respondent:

"The feasibility studies is part of the planning at the beginning…with the traffic data, we identify alternatives….based on the feasibility studies, selected road network will be upgraded because it will tell you this is the problem, this was the data collected, analysed and summarised and from the analysis, the output, these are the recommendations, but then you as a client may decide to say…this is my budget, I could only have this and that, and so we prioritise based on feasibility and costs."

When asked if there was a way to verify or audit the feasibility outcomes, the respondent answered: "*There are people that will vet the feasibility studies from the client side… the client does not take whatever they give. Government outsources most of the services, but they have qualified resources/people in- house eg, qualified transport engineers. When the consultant is given the job, they will see if the guys are talking nonsense or not…they will vet the feasibility studies and they also give it to an independent organisation like SANRAL to look at it also."*

This suggests that the feasibility study was done in consultation with the client. However, the vetting process does influence the outcome of the feasibility studies in favour of an individual or to make the project look more attractive. It only makes room for improvement, as suggested in the respondent's statement:

"There is room for adjusting…if to say that the consultant is saying "for this road section that you are going to upgrade, this is the preliminary design……we as the client will say no, what you have presented does not make any sense, we propose that you expand this a little bit, we don't see any non-motorised infrastructure for pedestrian, we don't see anything for public transport ...So they address them in their various interests….yes…so auditing was done…."

Therefore, although there is room for adjustment, it does not necessarily mean that it was done in favour of a particular stakeholder or partner. The feasibility outcomes are merely challenged if the client does not deem it sufficient to satisfy the objectives of the project and users' needs.

Reference data

The feasibility study was undertaken with reference to the "Freight and Traffic Management Plan for the City Deep/Kazerne Freight Hub". This plan was based on previously produced future traffic model projections for 2020 (Arcus-Gibb, 2010).

Factors considered

Due to the nature and objectives of the project (expansion and capacity enhancement), the factors which were considered during the feasibility studies included operational life, capacity analysis (when it will reach full capacity, what should be done), accessibility (universal access), mobility, users' satisfaction, contingencies, non-motorised transport (walking and cycling); safety and security; comfort and convenience; existing and potential businesses in the area; proximity to distribution centres, information sharing with the public and natural environmental features. These were evident in the following statements:

"The aim of upgrading the roads in that area of city deep, was to make sure heavy road vehicles move around easily and also pedestrians to move around easily. So, both users and drivers were considered."

"…mobility of the heavy vehicles in the area ...free flow of traffic…so that they don't cause traffic congestion and accidents on the road."

"*…proximity to distribution centres...the warehouses, the fruit and veg"*

"*with stakeholders…private businesses, who have their operations there, were consulted"*

"*…yes, any road construction upgrade has to do an EIA by law.*"

Therefore, the feasibility studies for the city deep freight hub included local engineering consultants, entailed development and analysis of scenarios based on traffic data and CBA. Reference was made to the management plan for the area and the factors considered included technical, social and environmental aspects.

5.4.1.2 Case study 2 – The Gautrain

The feasibility study for the Gautrain was started in 1999. It was conducted in two parts, first by the government and then by the concessionaires. According to one of the respondents:

"there was that level of, let's say our own provincial feasibility…For the parties that were interested, they then had to go and do their own feasibility and look at the input specification in order to get the output."

Who was involved?

The first feasibility study undertaken by the government was done with international and local consulting companies and experts, in order to set up the concept of the green-field project. It included the economic studies and the SED (socio-economic development) and EIA studies and involved environmental specialists, business economists, socio-economic specialists and project managers. Members of a "provincial support team" also took part in the first feasibility studies. The provincial support team was made up of specialists and engineers appointed through a bidding process, by the Gauteng Provincial Government, to advise on transactions regarding the Gautrain project, steer the project and assist with managing the development of the project. The second feasibility study was thereafter conducted by the established concessionaire on design and technical aspects. The second feasibility study also involved international partners.

Involvement of international experts in the feasibility study for the Gautrain project was deemed important since it was a greenfield project in South Africa and required international expertise:

"…when the guys came in, they had to put it all together …because high speed or higher speed was not a skill that was locally available…so they had to look at international experts to get involved."

Therefore, the level of professionalism exhibited in the feasibility study for the Gautrain gave no cause for concern (GMA, 2011). This suggested that the involvement of both international and local experts in the feasibility studies helped to ensure that the study was adequate and thus reliable.

Processes and methods

The process used in conducting the feasibility studies started with an assessment of alternative routes and determination of routes for the project, considering heritage (social), technical issues, conceptual design as well as environmental concerns. Thereafter, economic, business and financial feasibility studies were conducted. In addition, demand modeling was done based on assumptions of travelling behaviour to determine the expected service demand during the 15-year operational period of the concession agreement, with a view to providing sufficient service capacity for the project. Further, cost-benefit analysis was conducted to determine the lifecycle costs to the government (affordability of the project), attract private sector participation, ensure a bankable project and transfer the risk to the party best able to handle it (GMA, 2011). The process and methods undertaken for the feasibility studies of the Gautrain project can be construed from the respondents' statements:

"In the feasibility studies, there was quite an intricate process, in all aspects of engineering and environmental…"

"Yes, most definitely, with any project we do route determination studies... and you refine that as you consider various elements. if you look at the Gautrain, it is through a developed area, so you have to look at which properties are you going to expropriate…and which properties to avoid, so all the heritage studies, technical studies that need to go into the route determination. Then you look at the tunnel, the groundwork studies and you employ various components that will inform the feasibility of the project… and then also you look at the economic development.… then you do the business case and financial studies that you need to do….to prove that they (the funders) are not going to be losing money"

Another respondent explained the processes in more detail:

"The project kicked off in 2005/2006 where they did conceptual design looking at the performance regime and the documentation around that, looking at the time table that we were going to follow, the operating procedures that we were going to follow, all those things that at that point in time indicated what the operational intent would be, how you would measure it and how you would move on…My understanding was that some high level feasibility was done which then resulted in us being able to say this is what we want out of the system…the output specifications (performance indicators established by the province, in consultation with the provincial support team and appropriate stakeholders, for example, through third party agreements with local authorities) *started driving what you are trying to get to be feasible because you have to meet that requirement and then in terms of the design, it started influencing …say you have to meet this requirement otherwise you are not going to have the output that's required on this… So there is an output spec; we did not say, the train must look this such and such. It was a case of this is what we want. We want a train that can run from the airport to Sandton in 15 minutes…they then had to go and say okay I propose that we design from this level so that the whole design in terms of what happens on the track level, what happens on the trains, the nose, speed profile …they then had to come up and say I propose this rolling stock and its available in the market, that can comply and bring you what you want.*

Demand modeling was undertaken. However, the demand was conservative, which resulted in underestimation during the operational stage. The underestimated demand was partly as a result of the adoption of an international model in an unpredictable local context. According to the respondents:

"… our systems are always built on the basis of one thing you must do right at the beginning, is make sure that the demand is there….so we demand modeling was done".

'What I found was that the assumptions that we used during feasibility on the demand, it also comes down to who you use as your consultants…. even on the provincial side, they had a company in the UK that was involved, that assisted with the demand modeling based on which the guys said 'in a running set up, this is the typical behaviour'"

"Purely, it was a green field project; no other project had been dealt in this manner… but we're incredibly different from other places in the world. Very few places in the world have two cities that are 50km apart that function with each other. In the morning, people come from Pretoria and go into Johannesburg city centres and people from that end go in the other direction. And that in itself was a model that nobody was going to be able to compare…"

In summary, the processes and methods entailed development and analysis of alternative actions based on the outcome of the studies conducted including demand, financial, technical and socio-economic studies done. In addition, analysis of the demand and output requirements of the system were undertaken. The feasibility studies also incorporated all costs that will affect the project in its life cycle. These findings suggest that the outcome of the studies potentially influences the performance presently. What was envisaged and desired to happen during the operational stage of the project (including cost containment, demand and service capacity, and overall operational intent) was considered in the feasibility studies undertaken. Thus, a relationship between the processes and methods and the subsequent performance of projects can be deemed to exist.

Reference data used

During the feasibility study, reference was made to traffic data modelled from international perspectives. Information on costs were obtained from as well as benchmarking against international examples, in-depth discussions with main total rail system suppliers and by visiting some systems in Britain, Europe, South East Asia and United States. Local rates (costs) from manufacturers and suppliers were also used for civil works. In addition, legislation and exiting reports was refereed to, especially with regard to environmental aspects, as suggested by a respondent:

"The methodology covered quite a bit of the legislation in terms of the environmental section…a lot of monitoring data, wetland studies, specialist studies were referred to."

Therefore, during the feasibility studies for the Gautrain project, reference was made to both existing and new studies, as well as legislation, reports and information from local and international contexts in order to ensure that all aspects that could affect the project while in operation were covered.

Criteria factors considered

The factors considered in the feasibility studies for the Gautrain included demand, costs, contractual arrangements, risks levels, and funding options to achieve the project's objectives. These factors were related to affordability of the system in terms of what the government can afford to pay over a period to sustain the system given the revenue, risks and profit. For instance, the feasibility studies incorporated financial analysis of macroeconomic assumptions, capital expenditure, operating and maintenance costs and revenues, and financing costs, related to the potential "Build, Operate and Transfer" concessionaire who would invest in, construct, operate and maintain the system. It was largely related to the bankability of the project because for the project to succeed. It had to be financially viable, given typical sensitivity scenarios including construction cost overruns, project delays, reduced usage, higher operating costs, change in interest and exchange rates as well as inflation. The financial analysis was important to ensure private sector interest and competition in the tender process (GMA, 2015). The studies done were about what constituted sufficient number of passengers; as well as acceptable travel fares, profit and risk levels, investment levels to realise affordable government subsidy level, as revealed by different respondents:

"…your demand sizes up the size of the interest factor…no matter how much money you have or may not have, you have to be able to accommodate the size of the demand. Your demand drives everything, it drives the financial model, at what rate money is spent… how many coaches you are going to actually need to run the system for the entire concession agreement."

"*there were two big things…one is the demand forecasting…if there's a gap between the provincial forecast and the concessionaire forecasts, that's now where the risk comes in, so they move the risk off the passenger numbers not materialising, they moved that to the province, so that is one big item…so a lot of the feasibility and the calculations that were done had a lot to do with the perceived demand, what sort of levels, how they would materialise and therefore what sort of income streams can be expected coming out of that… if you don't have the passenger numbers to support that then it won't be viable".*

"On the other side of the feasibility, we then sat with how much this thing is going to cost because… doing it for 10,000 passengers…with expensive high-speed technology…at least they wanted to know that the gap between cost and demand would at least make it feasible. ..they had to bring it in at affordable levels given what was predicted on the passenger side"

"…The requirements from Treasury is that a project, for it to be regarded as feasible, has to be affordable in its entire life cycle. This means inclusive of the operating costs, is this project affordable? So there's the planning cost, the actual execution and acquisition cost of the system, and the operating costs, and the demand comes back again because if you are unable to collect the revenue that is required to be able to offset the capital and also the subsidy because there's a pop-up on the subsidy that is required to be able to make sure that it remains a viable product. Now if you cannot collect your revenue during the operating period, you'll not have an affordable system because then it means government is funding the entire thing. So, you have to balance, how much subsidy do you pay in and actually you also have to balance…for a system to have this level of demand, if we had set the price to a level where there is no subsidy at all in public transport, then the cost would have been double what it is today to travel on the system. So you have to balance the social demand and the economic demand…then in that balance you will be able to decide am I adding the subsidy, and if am adding the subsidy, can I get as much of it as possible to go into the price of the ticket…but you get to a point where it is unaffordable and people won't use it and it will remain a system that is only used by certain people. So, you have to balance the two during your planning phase and on top of that, you then put the cost of the actual infrastructure itself …."

Further, feasibility also meant that the benefits accruing to the broad community, including the value and quality of life and travel time savings, sometimes measured in monetary terms, had to be higher than the cost of undertaking the project. Further, funding options available in the market were identified and assessed to ensure that most risks were consumed and that as far as possible, the overall objectives of the project would be achieved (GMA, 2011). Moreover, the risks (including the nature, probability and magnitude) that could impact on the project financially had to be identified in order to develop mitigation measures for operations (Bracarense *et al.*, 2016). These risks include taxes, exchange rates, inflation and interest rates, fares and toll charges by alternative public transport systems as well as potential ridership (GMA, 2011).

In addition, technical factors including design (given topography) and speed were incorporated in the feasibility studies, especially since these affect the cost of the project, as informed by a respondent:

" When this thing started off, as soon as you cap it off and you give it the 45 minutes and you say that's the time, obviously you cannot have a station ever 500 metre or 1 km apart because then the trains will have to accelerate and soon as they come up to speed they have to come down, so the output specs even went so far as to dictate how far your stations can be apart so that's why you'll see that the above distance of stations ranges between 5 and 7 km apart except for one…therefore in the main, they felt you cannot have as many stations because this system is performing original level sort of train service, it's not every stop, whereas you think about the metro station where the stations are very close to one another…it's like the class of roads where you have streets, highways and so on. …the main difference between us and PRASA is the speed at which we run and the spacing of stations because you need distance to build the speed. Therefore, the function that we perform is a different one."

"One of the other things was cost of land and then the cost of going underground. In theory, we could reason that if we went above ground, it would probably have been cheaper from a tunnel point of view, but the expropriation cost of having to knock down blocks of flats in the way …so in the feasibility, they had to come up with this balance to say right to make this thing work so much of it can be in a tunnel and then it will still be viable and then viaducts…So all those sort of things have to be taken into account."

Other factors which were considered include economic impacts such as travel cost and time savings, accident cost and vehicle operating cost savings, the potential economic efficiency and effectiveness of the system when viewed as a whole (GMA, 2011:26). Social benefits including public participation, universal access, preservation of heritage, and environmental comfort were also considered as relayed in the following statements:

"We make sure that there is stakeholder engagement with all our stakeholders…the guys doing the feasibility studies, they interact with our stakeholders, the municipalities and the department of roads…we make sure that we show the plans that we have, we also give input on the plans that they have so that we make sure that there's integrated network that we're planning towards…"

"…the fact that you are going to divide existing communities…the historical stuff, whether there were graves in the area. They had to make sure that for each and every one of these, that they were aware of what was on the ground to not add to the complication…."

"Socio-economic aspects covered public participation, rural people... remember the alignment was going through, transgressing across municipalities."

Furthermore, environmental issues were considered in the feasibility studies in terms of preservation of natural habitat and regulatory requirements in line with the National Environmental Management Act (NEMA). This was revealed in the following statements:

"…obviously there were lots of environmental issues. Going underground with the tunnels, you sit with issues like water and water increases and the water table …. Then the design also had to avoid affecting water courses. It had to look at things like elevations crossing the river, running through the mountain above ground or below ground. All those things had to be considered on the geo level, in schedule 1 part 1. Somewhere along the line, some of the things that were specified in terms of the output were the noise, the visual impact, the landscape…obviously flora, fauna…we've got areas for example, if you come from the airport and just before you get to Marlboro, there's some swamp areas around there, a lot of bird life. So what we picked up at some point as the train started running, that all of a sudden, at certain times of the year, you've got guinea fowls that are in the way of the trains and they misjudge themselves because the trains are moving very fast. So all of those things had to be taken into account when the design was done and you're also expected to mitigate it. So in terms of the swamp areas, those are usually environmentally sensitive areas which you then have to make sure that you don't disturb the ecosystems. After they built Midrand station, because of the embankment that was caused by the rail alignment, it has resulted in new swamp areas developing which weren't there…on google earth, you cannot see green spots where there was a lot of water and settlements and areas where 7- 8 years ago, you might not see that…we also had to deal with environmental pollution from chemical industries upstream and monitoring and mitigating downstream contamination and that is where there are some major risks because if you now sign a contract and say am going to build this thing and you pick up major environmental issues that you did not budget for, it means that you have to be able to absolve that and that means you have to do your homework to say I have to

move trees because they are indigenous and I have to go through here I can't go anywhere else, otherwise am going to have a problem…".

"The environmental part was actually massive because this was the first change of regulations for new environmental laws…This was one of the first times that we had to start stringent environmental regulations that called for the EIA studies, etc. So that time, it was quite a bit covered, traverse through many wetlands, a lot of it was covered. … It covered planet, we didn't just look at environmental stuff as per "green" environment. We looked at it as the socio-economic environment as well, that was what was included there. So as part of the feasibility, it was also social, the people aspects."

Moreover, as earlier stated, the performance indicators established as output specifications for the Gautrain project were also incorporated in the feasibility studies:

"The 25 items on the performance regime was also used to say this is what we want; we expect something that is reliable up to this level, how you do it, what materials you use to get it there, what management systems you're using, the type of tech you're using, the kind of systems that you need to keep it there, those weren't specified…like these are the inputs that you need to use…so all those things."

Inclusion of the output specifications was important to ensure that key performance indicators were established and monitored (GMA, 2012:26). The items included aspects related to safety and security, operational efficiency of trains and bus feeder and distribution system, capacity and state of infrastructure.

Furthermore, it was important to identify structures or institutions for monitoring the established performance indicators during the operational stage. This way, the expected performance was assured to an extent:

"The GMA has got the responsibility to manage the Gautrain on behalf of the government. …we've got a PPP contract that we have to manage and to the extent to which you've signed the contract, you have to make sure that deliveries happen against that contract."

The above discourse on the criteria factors revealed that the factors considered and incorporated in the feasibility studies for the Gautrain included the type of project (being a green-field project), demand, service capacity, operational efficiency, technical (design), public participation, environmental (preservation of natural spaces), social benefits and heritage, safety and security, economic (revenue, costs and funding), and institutional factors (being a PPP project). These findings are consistent with views expressed in Yun and Caldas (2009) which determined that decision variables that influence feasibility studies include type of project, cost, benefit-cost ratio, economic feasibility and impact, attitude towards the project, environmental impact, financial feasibility, consistency with government plan and project specific factors such as vibration, noise and design.

In summary, the feasibility studies for the Gautrain involved international and local expertise. Cost-benefit, financial, environmental, technical and socio-economic studies were undertaken, in view of alternative choices. Reference was made to international and local evidence. The factors considered were social, environmental, economic, financial, technical and institutional in nature. These factors were deemed to be influential on the sustainable performance of the Gautrain system and therefore were considered in the feasibility studies.

5.4.1.3 Case study 3 – The N12 (P186/1)

Who was involved?

The feasibility studies was carried out by an engineering consulting firm, in conjunction with the design directorate of the GPDRT. The study involved technical specialists and engineers.

Processes and methods

Design studies were conducted since the aim of the project was to reconstruct the base of the road and rehabilitate the route. Stakeholder consultation was also done, as informed by a respondent:

"*There were seven councillors affected, they agreed on a community liaison officer… there was no political favour….to balance all the wards to avoid stakeholder crisis."*

Reference data used

Reference was made to the initial design documents as well as maintenance reports on the road project.

Criteria factors considered

The factors considered included environmental issues, traffic, quality of the road, safety and technical aspects. In addition, the cost of the project and benefits to the users in terms of improving safety, businesses along the road, as well as travel time savings were incorporated (GPDRT P186/1 Briefing Notes, 2016). Public/stakeholder participation was also considered.

In summary, the feasibility studies for the N12 road involved experts from an engineering consulting firm, with an oversight by the client. The feasibility studies entailed design studies and stakeholder consultation. Reference was made to existing design and maintenance documents. The factors incorporated in the feasibility studies included public interest, as well as costs and benefits including travel time savings and enterprise retention or generation along the route.

5.4.1.4 Case study 4 – The D1027 (Cedar Road)

Who was involved?

Engineering consultants undertook the feasibility studies for the D1027 (Cedar road). The local arm of the entity, which has an international base, was appointed by the GPDRT to conduct the study to rehabilitate the degraded road. Environmental specialists and technical experts were also in participation.

Processes and methods

The feasibility studies entailed traffic counts, examination of existing condition of the infrastructure and assessment of pavement capacity as well as alternative structural materials to enable sustainability of the road for a period of 20 years. An assessment of the costs and user benefits associated with the project was also undertaken.

Further, the funding and contract structure was considered as the project was partly funded by a private developer, as informed: *"There was a contract…because they must put it on the national treasury account. It's like a joint venture, but in a way of funding the project."*

In addition, the quality of the existing structure and its capacity given the projected traffic were examined during the feasibility studies. This was important because the aim of the project was to rehabilitate and improve the capacity and quality of the road to be able to accommodate expected traffic over a period of 20 years. Moreover, the processes and methods for the feasibility studies for the rehabilitation of the D1027 (Cedar road) entailed an assessment of costs and benefits to users, as well as other stakeholder interests.

Reference data used

Reference was made to traffic data existing on the road as well as structural design reports on the road.

Criteria factors considered

The factors considered in the feasibility studies of the D1027 (Cedar road) incorporated traffic demand, capacity of the road, the condition of the road being a threat to users' safety, stakeholder interests and needs, as well as environmental factors. These are evident in the following statements:

"The demand on the road was considered….the traffic…"

"That area is DA-governed … they were involved, they had to be consulted…meetings ….and the project was not easy. They had to be convinced of the progress that the project will bring in the area…..there was also community unrest… people were looking for cycling lane which was not accommodated."

On consideration of environmental issues: "*…on this one, we had a little problem. It was a wetland and therefore waterlogged….by nature, so we tried to find a specialist to come up with results on how we were going to solve that issue…. he analysed the area and found that the road can still be built there, it's not a serious problem…."*

In summary, the feasibility studies for the D1027 (Cedar road) was conducted by engineering consultants and entailed oversight by the GPDRT. The study involved assessment of existing structure and traffic bearing capacity of the infrastructure, as well as public participation and consultation. The criteria factors considered included quality, safety, traffic demand, stakeholder needs and interests, institutional factors for funding and maintenance as well as environmental elements.

5.4.1.5 Case study 5 – The K46

The feasibility studies for the K46 entailed assessment of traffic scenarios, environmental sensitivities, and determination of spatial integration and land use planning initiatives.

Who was involved?

The feasibility study involved planners and economists. It also involved local engineering consultants appointed by the GPDRT to conduct the study.

Processes and methods

The processes and methods included development and assessment of traffic scenarios in order to model the route based on expected growth in usage volumes. The feasibility studies also entailed an environmental impact assessment, economic analysis, as well as site surveys.

Reference data used

In the feasibility studies if the K46 road, reference was made to existing traffic data and projections of traffic estimates for the future, public information, environmental screening reports, and geo-spatial information and development frameworks for the area (GPDRT Report on Stage 1, 2017).

Criteria factors considered

The factors considered during the feasibility studies for the K46 included land use potential, population and expected traffic growth rate in the area, design, speed, road user benefits (including safety, travel time savings, fuel cost savings), project resourcing (funding), network alternatives given projected traffic growth rate (for instance, e-tolling or not, additional networks, mixed traffic), costs, and environmental aspects (geology, heritage, biodiversity, water resources, geo-spatial information, private developer initiatives, land use planning (GPDRT Report on Stage 1, 2017). These were also evinced from a respondent's statements:

"Environmental, social, geo-spatial information, land use planning, spatial development frameworks from the cities from the province and private developer initiatives, public information, model (the route, how it's going to change), the scenarios, how the project is going to change with

expected traffic growth, expected population growth, expected developments to the area; economic analysis, project resourcing (where you're going to get the money and whether it is feasible in terms of the design) how much its going to cost (from developers, or our coffers or from Treasury), the economic benefits, the CBA, select a few items for analysis (user benefits like the amount of time it usually takes a user to travel from point A to point B, vehicle maintenance, operations, how much are we going to cut down for vehicle maintenance, how much time to cut for the user, how much they going to save and basically the focus where that route is considered, it could be mixed traffic or public transport the travel time)…land issues."

Thus, the feasibility studies for the K46 involved engineering consultants, and entailed assessment of traffic scenarios, existing land uses, environmental and spatial development factors. It also included cost-benefit analysis as well as project funding alternatives.

5.4.1.6 Case study 6 – The BRTs

Despite the arrangements that were made to provide an integrated network in 12 South African urban cities, a comprehensive feasibility studies or transportation study was not conducted for the BRTs, as was undertaken on the Gautrain project. Statement by some of the respondents captured this view:

"A decision was taken back in 2008… by the Department of Transport, based on the Public Transport Strategy 2007… that BRTs will be implemented in South Africa. So, there were no feasibility studies conducted as the decision was taken to implement BRTs."

"We did financial studies, heritage review, while doing the design…but all these processes were happening while we were under pressure to deliver the project."

Therefore, some studies were conducted at the project initiation stage, albeit incomprehensive, as presented in this section.

Who was involved?

International consultants (in Cape Town) were involved on the implementation of the BRTs. Local environmental companies and engineers as well as international expertise were involved in the CoT implementation of the BRT, as captured by a respondent:

"*…a lot of the expertise came from Ireland; the concept was new… these were the guys that developed the BRTs…. and then companies like ours brought our expertise too…my role (private consultant) was also to transfer skills and assist in how to build up the department that will be taking care of the system…"*

Therefore, local and international experts were involved in the brief scoping study on the BRTS.

Processes and methods

Scoping studies as well as business and operational plans for the entire system were drafted for approval (DoT, 2008). The processes and methods entailed development of options and designing based on the developed options. In addition, demand modeling with regard to number of people and businesses within the identified areas and along the routes. In addition, financial studies were undertaken to determine ideal pricing (based on existing travel fares) and costs. Further, public participation was done. These processes and methods were captured in the respondents' statements:

"We did demand studies …traffic and business/vendor counts …BRT depends on the numbers in the catchment areas. Basically, we looked at people, the businesses that were along that particular chosen route …then we had to design a network, come up with many options…. so based on the demand model…we are not developing the network in a green field so some of the routes affected public transport existing, the buses, the taxis…..We also did a financial study…At the time, the data was outdated but we used extrapolated information…we had to be able to determine what would have been the ideal price that passengers would pay. So we had to compare what buses were charging to travel a similar route...we also did a household income survey to compare the household income and we came up with a price per km…"

"There were also studies done in Cape Town, by international consultants…but they didn't include the capital costs of the infrastructure system and the buses. They may have done feasibility studies but not from the total cost point of view… "If you look at the overall cost of these BRTs, we may not see the full costs because some of the costs may be hidden or carried by departments within the city and not attributed to the BRT itself and so we will never get the full picture of the costs…the security, monitoring, the vehicles, the maintenance and so on, all of that is part of the costs of presenting the service and you know what the costs are and what they should recover. We

don't know. …some of those costs are significant costs, you have to include them in infrastructure costs of the system in judging whether the system is financially feasible or not and whether you should carry on with it. We don't know the future subsidies, the future costs…it is difficult to find the costs and so it is difficult to decide if conventional buses will not give us more services at lower cost than the BRTs."

"We then had to have a discussion with the heritage council of SA with the sole aim of reserving some of the owned buildings and their own heritage, like in the city of Tshwane, in the CBD, the early times of the city, there used to be a tram, when we were undertaking the heritage review, we discovered that there were trams and historians basically told us…there were old synagogues...on the environmental side, we also had to get approvals for water use license (environmental compliance) and also to make sure that we protect the streams and basically the wetlands (preservation of natural features) …"

"you now have a fair understanding what numbers, the next thing then was to design the pavements, based on the number of axial loads and imported works and that followed by the engineering and design specifications. …but all these processes were happening while we were under pressure to deliver the project…within 3 years, the planning and implementation was done…the processes were signed off by the City Council for approval …"

Therefore, the processes and methods involved in the studies undertaken for the BRTs included demand modeling, public participation (with regard to preservation of heritage sites), environmental and financial (including fare comparison and costing) studies. However, the financial studies did not include the total cost of the delivering the system, including operating costs (to the detriment of the system).

Reference data used

For the scoping studies and business and operational plans undertaken for the BRTs, the Gauteng Infrastructure Master Plan was referred to as the BRTs are part of the master plan. In addition, existing Household Income Surveys (albeit outdated) were referred to.

Criteria factors considered

Due to the extent of planning study undertaken for the BRT system, this section includes information regarding aspects that were considered and those that should have been considered in the view of the interview participants. Some important factors, which could affect the performance of the BRTs performance at the operational stage were considered, but inadequately, to the detriment of the system at present, are also presented.

Implementation of fare system through a common electronic fare system was laid out in the Network Plan. However, adequacy of the fares and pricing were not contemplated in detail. As a result, the fare was set a low level, causing the system to be heavily dependent on subsidies (expensive and unsustainable), as suggested by a respondent:

"*Certainly there were studies that showed that they would be able to operate these BRTS without subsidies, but there were always questions at the beginning…I always questioned that at the beginning because low densities may have about 80 hours of operation… this is part of the lack of feasibility of these BRTs because your entry fare should be at an adequate level because you can't operate….with the inflation once you're already in the service itself…it is difficult".*

"…they introduced the first one (BRT) *here in Johannesburg and pitched the fare too low, at the level of taxis or just below the taxi fares. It was too low; they should have pitched it at a higher level, so that put them on the wrong footing. So, from day 1, they needed subsidies."*

Preservation of the natural environment, widening of roads as well as traffic, were considered. However, these were seemingly considered during construction as can be construed from the statement: "*They looked at the removal of trees and things like that and the impact of traffic, and replacing with new trees, the widening of roads was problematic too"*

Institutional and funding frameworks to facilitate implementation as well as to manage and regulate the networks were laid out in terms of the Network Plan (Pillay and Seedat, 2007:404). Funds for the BRT system comes from the National Treasury. However, the operator is private. The Action Plan provided that the transport authority will be responsible for the fare revenue, and operators were contracted to provide particular services. However, the contracts hugely favoured the contractors as there is no revenue risk borne by them. According to the respondents:

"Before the world cup in 2010, they created the structure where the City purchased the buses, then they transferred the buses to an operating company, a private company, Piotrans, they operate phase 1A and 1B. they have a 12-year gross contract with the City, a negotiated gross cost contract with the City."

"...in that first phase, the City of Johannesburg (CoJ), at that point in time. …the contractual relationship in phase 1 was very real towards the operator himself, basically no risks to the operator…they have a gross cost contract which is typical of agreements, which is the operator has no revenue risk, they produce the service based on a timetable, they collect the fares and then hand over the fares to the authority and the City pays them rate per km."

The design was also not given considerable attention, and this is currently a concern, as captured by the respondents on different aspects of the design specifications:

"BRT designs are normally overkill, the axial loads; some of the buses are train buses, they are heavy and obviously operating on peak-time and off-peak, they decided to come up with these buses…it is a good thing because they are very close to the ground so they were unlikely to capsize…so when you have an accident, it is unlikely to capsize." On the other hand, another respondent proffered: "*the question is whether we should have BRT Light, like conventional buses using the main roads, instead of all of these specialised buses on the right-hand side and not on the left-hand side, because the stations are designed that way, in the middle of traffic and you can't use it for anything else …or you have to have buses with doors on both sides like some of the few introduced in phase 2 in Johannesburg. So, there's a question about the long-term thinking around the BRTs…".*

The above suggested that design was not given considerable attention to ensure that sustainability of the system is attained.

Other social factors including impact of the system on business and the quality of life of the community members, as well as safety were considered, as suggested in the following statements:

"We considered the impact of the project on existing businesses like vendors along the route…we looked at the value chain…as part of the agreement with the city operators, the City allowed the operators to …the station has to be cleaned, there must be a person, there must be people who

collect cash at the stations. So we employed some of the people that were affected by the project. So we took some of the hawkers …impacted and affected hawkers …so the bus stations are manned by taxi operators who are supposed to employ the people affected directly."

"Safety was considered…. the bus speed is less than 60kms per hour. … drivers were trained not to drive recklessly…remember these drivers were taxi drivers who are basically reckless, so they had to undergo a training process to drive the BRTs. …metro police Tshwane were tasked to run workshops to educate the public about the buses and all that…we made flyers to educate the public …the new seat belt were novel to a lot of people, we had to publish them to make people aware of all those things"

In summary, a comprehensive feasibility study was not undertaken before implementation of the BRT systems. However, local and international experts were involved in the development of alternatives and planning and designing of the BRT systems in the three different locations. Reference was made to the Gauteng Master Plan and household hold surveys were undertaken. The representatives of the communities affected were also consulted. Factors considered included safety, design quality, environmental (sustainability of the project on waterlogged areas), preservation of heritage sites, stakeholder interests (integration of entrepreneurs into the operation of the system, traffic/demand, institutional frameworks for management and operations, as well as fares. However, studies did not consider the appropriateness of fares, sustainability of design specifications, and the demand for such expensive, specialised brand in low-density areas. Thus, these inter-related issues threaten the sustainability of the BRTs. The cost-effectiveness and the value-for-money accruing to the investment is questionable. It therefore appears that although some studies were undertaken, there was no marked and comprehensive feasibility stage or comprehensive study which was dedicated to identifying factors that may affect the project at the operational stage. Design and feasibility were merged, and implementation was undertaken right away without adequate consideration and development of alternative scenarios regarding all performance-influencing factors.

5.4.1.7 Case study 7 – The Tolwane Bridge D603

In the feasibility study for the Tolwane Bridge on road D603, the failure of the infrastructure and strategies to rehabilitate were the focus.

Who was involved?

Local consulting engineers and experts conducted the feasibility and detail design studies. The consultants were appointed by the GPDRT (GPDRT, 2015a; b; c).

Processes and methods

Site surveys were conducted for hydrological and hydraulic analysis, regional analysis of historical data, determination of flood peaks, rainfall data, geotechnical surveys, and pavement design analysis. Technical and regional data were collected to develop and evaluate alternatives to rehabilitate the failing structure. In addition, erosion protection measures were developed since the area was flood-prone. Further, environmental issues were attended to including liaison with legislative bodies such as the Department of Water Affairs. The consultation related to obtaining relevant water use applications and license since the reconstruction of the bridge entailed crossing or running along a watercourse. An implementation framework was thereafter developed based on the findings (GPDRT Detail Design Report, 2015a).

Reference data used

Reference was made to rainfall data, historical data, traffic data, and regional master transport plans. As-built drawing were not available because the bridge was previously under the administration of another province (North-West).

Criteria factors considered

The feasibility study for the Tolwane bridge incorporated climatic and environmental considerations including rainfall, erosion and flooding propensities. Technical factors were also considered. These included surfacing and geometric design requirements. Important factors like the traffic volume, traffic actions, gradients and maintenance capability were incorporated to determine alternative surfacing options (GPDRT Detail Design Report, 2015a).

In addition, costs were also evaluated. These related to capacity improvement options including *inter alia* construction of additional culverts, additional bridge adjacent to existing culverts and construction of a new bridge (GPDRT Stormwater Report, 2015b). Further, legislative factors relating to environmental compliance and licensing were considered.

In summary, the feasibility study for the Tolwane Bridge involved local engineers and consultants. The feasibility studies entailed technical, environmental, regional and locational investigations. Surveys and cost evaluations were conducted with the aim of selecting the most suitable option to improve and sustain the capacity of the bridge. A reliable implementation framework could not be developed without adequate feasibility studies (Bracarense *et al.*, 2016). Feasibility studies attend to the various options (including costs, design and impacts including environmental and aesthetically desirable ones) and provide a good basis for decision-making and selection of alternatives (Saroop and Allopi, 2005; GPDRT Stormwater Report, 2015b; Bracarense *et al.*, 2016; Marcello *et al.*, 2016).

5.4.1.8 Case study 8 – The K57 (R82) (Phase 1)

Who was involved?

The feasibility study for the K57 road was conducted by experts from a local engineering consulting company. The entity was appointed by the GPDRT, whose design directorate was also involved in overseeing the study in conjunction with the engineering consultants.

Processes and methods

During the feasibility study for the K57 road, traffic studies were conducted using counts of vehicles and passers-by. Site and topographical surveys were also conducted to determine site specific factors which can affect the project. Thereafter, alternative strategies were developed and analysed to select suitable options for design, construction and future maintenance.

Reference data used

The documents referred to during the feasibility studies included existing traffic data, initial design reports, database of tendered rates, as well as site survey data for structural and topographical details.

Criteria factors considered

The factors incorporated during the feasibility study for the K57 included exiting conditions with regard to land uses, public transport facilities, state or quality of the infrastructure, as well as environmental and climatic conditions.

In addition, the traffic demand, design, speed, costs were assessed in order to develop possible alternative strategies to undertake the improvement required. Drainage and geological materials and capacity aspects were assessed. Further, funding and financing options were considered.

On the K57 project, the feasibility study involved local experts; traffic and topographical studies were conducted and alternative strategies were developed based on those. Existing reports and data were referred to and criteria factors incorporated included quality/state of infrastructure, existing public transport facilities, and environmental conditions.

In summary, on all the projects, expertise was crucial and procedures and methods followed during the feasibility studies. Reference was made to existing documents and various factors were considered. These findings are summarised in a matrix in Table 5.2.

Table 5.2: Summary of qualitative findings on feasibility studies

Cases		Project type	Project objectives	Findings on feasibility studies			
				Who was involved	**Processes and methods**	**Reference data used**	**Criteria factors considered**
1	City Deep freight hub	Roads	To increase capacity of existing networks	Engineering consultants and independent/strategic auditors	Traffic studies; development of scenarios; CBA; vetting and auditing of studies	Traffic counts Freight and traffic management plan for City Deep	Accessibility (universal access); traffic; capacity analysis; movement (free flow of traffic); non-motorised transport (walking and cycling); safety and security; comfort and convenience; existing and potential businesses in the area; future capacity/ operational life; proximity to distribution centres; natural environmental features
2	Gautrain	Rail	To ease severe traffic congestion and promote public transport usage	International and local experts	Development and analysis of alternative actions based on the outcome of the studies conducted including demand, financial, technical and socio- economic studies done; analysis of output requirements of the system; analysis of life cycle costs	Legislation (NEMA); reports and information from local and international contexts	Demand, service capacity, operational efficiency, technical (design), public participation, environmental (preservation of natural spaces), social benefits and heritage, safety and security, economic (revenue, costs and funding), and institutional factors (being a PPP project).
3	N12 (P186/1)	Road	To increase capacity of the road network; rehabilitation	Engineering consulting firm (in conjunction with the GPDRT's design and technical specialists)	Design studies Stakeholder consultation	Initial design documents Maintenance reports on the road.	Environmental issues, traffic, quality of the road, safety, technical aspects, cost of the project, impact and benefits to the users (businesses along the road, travel time savings) and public participation
4	D1027 (Cedar Road)	Road	To increase capacity of the road network and pavement integrity	Engineering consultants; environmental specialists; technical experts	Traffic counts; examination of existing condition and quality of the infrastructure; assessment of pavement capacity as well as alternative structural materials to enable sustainability of the road for a period of 20 years; assessment of costs; assessment of user benefits and stakeholder interests; analysis of the funding and contract structure	Existing traffic data; structural design reports	Traffic demand, capacity of the road, condition of the road being a threat to users' safety, institutional arrangements for funding, stakeholder interests and needs, as well as environmental factors (waterlogging).

Table 5.2 (cont'd.): Summary of qualitative findings on feasibility studies

Cases		**Project type**	**Project objectives**	**Findings on feasibility studies**			
				Who was involved	**Processes and methods**	**Reference data used**	**Criteria factors considered**
5	K46	Road	Redesign; upgrade from a single to dual carriageway	SMEC Consultants Design Directorate & Engineering	Development traffic scenarios in order to model the route based on expected growth in usage volumes; Assessment of the developed traffic scenarios to select best alternative; EIA; Economic analysis; Site surveys	Existing design reports Traffic data	Land use potential, population and expected traffic growth rate in the area, design, speed, road user benefits (including safety, travel time savings, fuel cost savings), project resourcing (funding), network alternatives given projected traffic growth rate (for instance, e-tolling or not, additional networks, mixed traffic), costs, and environmental aspects (geology, heritage, biodiversity, water resources, geo-spatial information, private developer initiatives, land use planning
6	BRTS	Rapid transit networks	Upgrade of public transport; and provision of alternatives for universal access and greater social cohesion	Engineering consultants; international expertise	Scoping studies (development and designing based on options on extent of coverage); Business and operational plans for the entire system were drafted for approval; Demand modeling (number of people and businesses within the areas and along routes); Financial studies (pricing in relation to existing travel fares, and costs; Public participation and stakeholder consultation (with regard to impact and preservation of heritage sites)	The Gauteng Infrastructure Master Plan; Household Income Surveys (albeit outdated)	Safety, design quality, environmental (sustainability of the project on waterlogged areas), preservation of heritage sites, stakeholder interests (integration of entrepreneurs into the operation of the system, traffic/demand, institutional frameworks for management and operations, as well as fares

Table 5.2 (cont'd.): Summary of qualitative findings on feasibility studies

Cases		**Project type**	**Project objectives**	**Findings on feasibility studies**			
				Who was involved	**Processes and methods**	**Reference data used**	**Criteria factors considered**
7	Tolwane Bridge	Bridge	Rehabilitation	Local consulting engineers and experts appointed by the GPDRT	Development and evaluation of alternatives to rehabilitate the failing structure; site surveys (for hydrological and hydraulic analysis); regional analysis of historical data; determination of flood peaks from rainfall data; technical and geotechnical surveys; pavement design analysis; assessment of environmental issues and liaison and consultation with legislative bodies such as the department of water affairs; development of an implementation framework (including erosion protection as well as rehabilitation measures) based on the findings	Rainfall data; Traffic data; Regional master transport plans	Climatic and environmental considerations including rainfall, erosion and flooding propensities; Technical factors (surfacing and geometric design and maintenance requirements); Traffic volume and actions; Costs (capacity improvement options including *inter alia* construction of additional culverts, additional bridge adjacent to existing culverts and construction of a new bridge; Legislative factors relating to environmental compliance and licensing
8	K57	Road	Upgrading; to improve capacity, geometric standards, road safety, and accessibility	Local consulting engineers; oversight by the GPDRT's design directorate	Traffic studies (counts of vehicles and passers-by); site and topographical surveys; development and analysis of alternative strategies to select suitable options for design, construction and future maintenance	Existing traffic data; initial design reports; database of tendered rates; site survey data for structural and topographical details.	Exiting conditions (land uses, public transport facilities, quality) of the infrastructure; environmental and climatic conditions; traffic demand; design and speed; costs; technical factors (drainage, geological materials, capacity aspects); funding and financing options

5.4.2 Cross-case analysis: Project feasibility studies

The projects studied were analysed across the cases to compare the findings. With regard to the feasibility studies elements viz-a-viz, the participants (who was involved), processes and methods, reference data and criteria factors considered. The findings were presented in a matrix in Table 5.3. The table contains a comprehensive listing of all the elements found in each of the cases, inasmuch as they appeared at least once in the feasibility reports and/or interviews. The findings are also discussed hereunder with reference to extant studies.

5.4.2.1 Who was involved?

Whilst most projects involved local consulting companies, the Gautrain involved international experts since it was a green-field project and such a project had not been done previously in South Africa. It is valuable and critical to include relevant subject matter experts in feasibility studies, especially where there is a likelihood of impacts, sensitive resources, design challenges and a high level of public controversy (Hyari and Kandil, 2009).

Although international experts were also involved in the BRTs, being a new concept in SA, the impact of their involvement was not felt on the project as there was poor consideration of the design as well as future returns from the project and this has adversely impacted on the project. The poor performance of the BRT projects could also be as a result of the length of time in which the experts were involved in the planning, which was not specifically delineated from the entire development process. As such, sufficient time was not afforded for a suitable design and business case development to the detriment of the project at the operational stage. Projects which have robust business cases and are developed from long-term plans (such as in the Gautrain project) are likely to be most successful (Villarreal *et al.*, 2016).

Table 5.3: Project feasibility studies: Cross-case analysis

S/No.		FS elements	Cases								
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
			City Deep hub	**Gautrain**	**N12**	**D1027**	**K46**	**BRTs**	**D603**	**K57**	
1	Who was involved	Engineering consultants	x	x	x			x	x		5
		Supervision & auditing by provincial government (strategic advisors)	x	x	x	x				x	5
		Local consulting companies		x				x	x	x	4
		Technical experts		x		x			x		3
		International experts	x	x		x					3
		Business economists		x				x			2
		Independent analysts		x				x			2
		Environmental specialists		x		x					2
		Socio-economic specialists		x			x				2
		Project managers		x							1
		Planners					x				1
2	Processes and methods	Traffic counts & modeling	x	x		x		x		x	5
		Development of scenarios/alternatives	x	x		x				x	4
		Analysis & refinement of scenarios /alternatives (route determination)	x	x			x			x	4
		CBA	x	x			x				3
		Site & locational characteristics analysis/survey (assessment of existing physical/structural conditions, pavement, geo technical investigations, etc)				x			x	x	3
		Conceptual design & scoping studies		x	x			x			3
		Business, financial & economic studies (private investment initiatives)		x			x	x			3
		EI & sensitivity studies		x			x	x			3
		Social studies (Stakeholder engagement/public participation; heritage)		x			x	x			3
		Operational studies						x		x	2
		Needs assessment	x								1

Table 5.3 (cont'd.): Project feasibility studies: Cross-case analysis

S/No.		FS elements	Cases								
			1 City Deep hub	**2 Gautrain**	**3 N12**	**4 D1027**	**5 K46**	**6 BRTs**	**7 D603**	**8 K57**	**Total**
		Context-specific processes (Hydrological & hydraulic analysis, determination of flood peaks, rainfall,)							x		1
3	Reference data used	Traffic data/plans (monitoring & projected)	x	x		x	x	x	x	x	7
		Existing project design & structural reports			x	x				x	3
		Existing infrastructure audit observations (on performance) & maintenance reports			x	x				x	3
		Benchmarking from international examples		x				x			2
		Environmental screening & regulatory documents (including wetland studies)		x			x				2
		Information from public, manufacturers & suppliers		x			x				2
		Local financial/tendered rates		x						x	2
		Infrastructure master plans (spatial & geo-spatial development plans & frameworks)					x	x			2
		Household income survey						x			1
		Rainfall data							x		1
4	Criteria factors	Environmental features (natural features, noise, flora and fauna, wetlands, water bodies, climate, etc.) and compliance	x	x	x		x	x	x	x	7
		Socio-economic environment (heritage, comfort, benefits, convenience, vehicle and travel time savings, etc)	x	x	x	x			x		5
		Technical factors (structural quality & design, geological materials, drainage, etc)			x	x		x	x	x	5
		Locality characteristics (existing businesses in the area, land uses, etc.)	x		x			x	x	x	5
		Condition/state of infrastructure			x	x	x		x	x	5
		Project funding (private investment/partnership)		x	x		x			x	5

Table 5.3 (cont'd.): Project feasibility studies: Cross-case analysis

S/No.	**FS elements**	**Cases**								
		1 City Deep hub	**2 Gautrain**	**3 N12**	**4 D1027**	**5 K46**	**6 BRTs**	**7 D603**	**8 K57**	**Total**
	Safety & security	x		x			x	x		4
	Traffic demand		x	x		x				3
	Costs and affordability (subsidy)		x			x		x		3
	Revenue & profits during operations		x		x		x			3
	Public participation /engagement; users' interest/ needs/satisfaction	x	x	x				x		3
	Pricing/fares		x				x			2
	Proximity to other land uses (including walking distances)	x			x					2
	Operational life/ full capacity of the project	x						x		2
	Institutional structures (for monitoring & management)		x				x			2
	Physical attributes (topography, intersections, etc.)		x						x	2
	Alternative transport modes (non-motorised), for integration	x				x				2
	Mobility and access	x	x							2
	Contingencies/allowance for future (eg. maintenance needs)	x								1

The findings revealed that a wide array of expertise was involved on the projects. On four of the projects (Gautrain, BRTs, D603 and K57), local consulting companies were involved. Technical experts were involved in three of the projects (Gautrain, D1027 and D603 bridge) while business economists, environmental and socio-economic specialists were involved on the projects. The Gautrain project is reportedly performing well (better than expected as relayed by the respondents), in various aspects including travel demand, satisfaction, safety and security as well as service quality due to the wide range of experts that were engaged. Involvement of multi-disciplines in feasibility studies is important since an assessment of various aspects of the project including technical, physical constraints, financing and contract negotiations, community liaison, costs, benefits and impacts, which influence its performance at a later stage, is entailed (Subash *et al.*, 2013; Schneider-Roos *et al.*, 2014).

Further, it is notable that reviewers were involved to review the feasibility studies outcome, as was done on the City Deep project. Supervision and oversight of the feasibility studies ensured that the needs of the users and achievement of the objectives of the projects were realised in the City Deep project. Peer reviewers can be selected from local and/or international consulting companies, economic experts, academics, committees, and multidisciplinary technical staff, and no formal procedure may be required (Naser, 2012: 236). Peer reviews involve persons who have the necessary experience and qualifications to be considered an equal or better than the feasibility studies team and therefore qualified to opine and provide a definitive opinion on the quality of the outcome (Mackenzie and Cusworth, 2007:9). Reviews and auditing ensure that the information is adequate before it is used as a basis for decision-making (Naser, 2012:236). Peer reviews of feasibility studies draft reports ensure that major deficiencies and omissions are taken care of, ensures objectivity, enhances the quality of feasibility studies and thus provides additional confidence in the outcomes (Hyari and Kandil, 2009:74).

Further, involving independent analysts, as found in the study, who may be third parties or previously uninvolved, unbiased, impartial and unaffected people, review and analysis, ensures that the quality of feasibility studies is improved (Mackenzie and Cusworth, 2007:9). However, resources spent on appraising, peer- and/or independent reviewing of transportation infrastructure projects at the feasibility stage should be proportional to the likely project cost, given its nature and complexity (Department of National Treasury South Africa (DONTSA), 2015; Murherjee and Roy, 2017).

5.4.2.2 Processes and methods

In the feasibility studies of the projects, it was found that scenarios were assessed and alternative strategies were developed based on traffic counts undertaken, site surveys, and household income surveys (in the case of the BRTs). Conceptual design and scoping studies were undertaken on three of the projects including the Gautrain, BRTs and the K46. This was because they were large-scale and new (Gautrain and BRTs) projects and therefore failure was not an option. However, the scoping studies undertaken on the BRTs was deemed to be inadequate. The life cycle costs for the projects and future operational structures were not considered extensively, to the detriment of the project at present. Scoping studies ensure that all potential impacts (including environmental and social) are identified and potential adverse effects and foreseen and planned for (Naser, 2012).

In addition to the scope and design studies, operational influences including costs, institutional structures for funding and management had to be assessed. Operational studies are relevant because by the time a project is operational, its success or otherwise is already determined by the decisions taken based on analysis of operational costs and revenues (Murherjee and Roy, 2017). Therefore, all the factors that could influence the project during the operational stage need to be investigated. These include project environment (physical, social, economic), financing and procurement, technical as well as context-specific factors need to be assessed. Thus, feasibility studies should have a clear operational focus (Allport *et al.*, 2008).

Site surveys are important in the feasibility studies process. Site surveys reveal topography and physical challenges which may hinder the construction and subsequent performance of the project. Site surveys also influence technical considerations such as the optimal route, geotechnical and structural design and material alternatives (AfDB, 2009). Further, surveys of the proposed project area disclosed potentialities for accessibility, availability of amenities (for NMT infrastructure) and environmental restrictions in the vicinity, which require special permissions (for instance, water licensing) (Halil *et al.*, 2016). In addition, analysis of the locality characteristics of a proposed project enabled examination of context-specific aspects, traffic hotspots and desire lanes, as well as social and environmental impacts of the proposed project in terms of expunging existing businesses and heritage sites (Subash et al, 2013).

Cost-benefit analysis (CBA) was also undertaken in the feasibility studies of the projects. This was important because sometimes, the costs of the projects exceed the benefits (Chatziioannou and Alvarez-Icaza, 2017:2). The CBA therefore ensures that life cycle costs are identified and weighted against the benefits of investing or developing the project (Subash *et al.*, 2013).

Vetting and auditing by independent and peer reviewers was found to be key in the feasibility studies process. Although the reviewers and feasibility studies team members may disagree on matters, review and auditing are essential to ensure that the study is comprehensive, fit for purpose, meets the needs of all stakeholders and standards as well as objectives of the project are taking cognizance of (Mackenzie and Cusworth, 2007:10).

Assessment of needs of the users and other stakeholders in feasibility studies was stressed since existing businesses and public transport facilities are incorporated into a proposed system. For instance, the BRT system (like the Addis Ababa LRT) incorporated private taxi operators into the networks as operators (Sabatino, 2017:2). Therefore, inadequate consultation with stakeholders to ascertain their needs and priorities results in failure of infrastructure projects as was the case with the e-toll implementation in the Gauteng Province of South Africa. The need for longer-term consultation during feasibility studies and more broadly formulated purposes and priorities for greater coherence to transport policy cannot be over-emphasised. Public involvement increases general awareness and acceptability of the project, and ensures meaningful participation, which is central to good decision-making (Naser, 2012:236). Active participation of all stakeholders ensures that concerns are incorporated as much as possible in project selection and this contributes to the acceptability and support of selected projects (Dey, 2001; Valentin *et al.*, 2012). Supporting these views, the OECD (2017:10) added that dialogue with end-users should be done early in infrastructure project planning to ensure good performance.

Additionally, consideration of end-users' interests is important because the primary need of mobility is associated with safety, security, proximity to daily opportunities, comfort, and convenience, as reflected in Malow's pyramid of human needs (Figure 5.2) (Chatziioannou and Alvarez-Icaza, 2017:8). Furthermore, close and meaningful engagement with the community can lead to careful management of impacts and delivery challenges that are eventually welcomed by the locals (Cascetta and Pagliara, 2013).

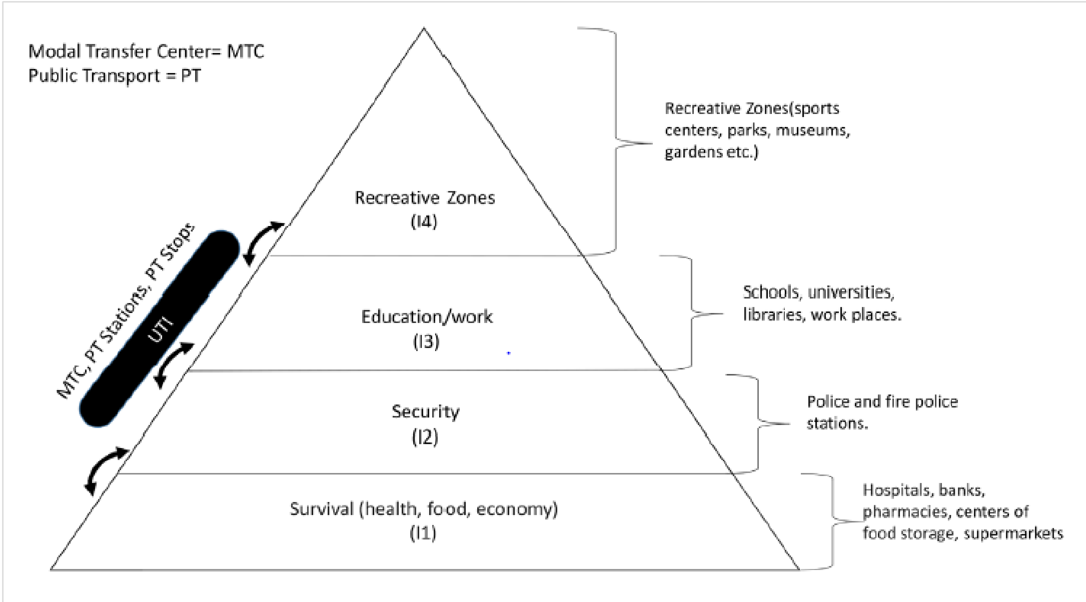


Figure 5.2: Pyramid of Maslow's human needs in relation to points of interests (Chatziioannou and Alvarez-Icaza, 2017:8)

Other studies, such as EIA, and environmental sensitivity analysis are vital aspects of feasibility studies. These studies ensure that all potential impacts are recognised and addressed in the EIA and measures are developed to overcome the possibilities of neglecting the significant impacts (Naser, 2012:235).

Economic and financial analysis were also considered important. Economic assessment is concerned with the worth of the project to the community, users and developers, with regard to savings in travel time, improved productivity, savings in vehicle, fuel and accident costs (Halil *et al.*, 2016:59). Financial analysis deals with the projections of returns on investment cost for the proposed development, the sources of funding, the institutional rules and regulations. It includes an analysis of all costs related to the project throughout its life cycle including operating costs and risks such as currency risk, credit risk, and interest rate risks as was done on the Gautrain project, but not on the BRTs (Subash *et al.*, 2013; Halil *et al.*, 2016:59).

In summary, the importance of developing and assessing alternatives before making decisions regarding infrastructure projects was emphasised (Hyari and Kandil, 2009). Risks and uncertainties (nature, probability and magnitude) must be identified considering future conditions and potential effects of alternatives. The identification of risks is appropriately done if they are initially identified and defined, and on which bases projections and alternative evaluations can be made before a decision is made (Bracarense *et al.*, 2016:308). This suggests that failure to progress through the study phases contributes to poor quality feasibility studies (Mackenzie and Cusworth, 2007:11; Hyari and Kandil, 2009). Following the procedures in feasibility studies ensures that the use of misleading and inadequate information is avoided and the disparities between the predicted conditions in feasibility studies and the actual conditions on site during operations is minimised (Hyari and Kandil, 2009).

5.4.2.3 Reference data used

In seven of the eight projects studied, traffic data and plans were referred to. Reference to existing traffic data enables assessment of traffic volumes and composition (for instance, vehicular and non-motorised) in order to predict potential of overloading and to make plans for accommodation of traffic (Asian Development Bank, n. d.; World Bank, 2008). The traffic volumes also justify the transportation infrastructure being proposed (World Bank, 2008). This is because traffic is an important element, which concessionaires look for (in public-private partnership projects) in terms repatriation of investments and profits. In addition, travel models from such data are also used to test the travel impacts of changes in economic development, land uses, fuel and parking costs (Federal Highway Administration (FHWA, 2006:49).

Further, existing reports including design, structural, and maintenance reports were referred to in three of the projects, namely: N12, D1027 and K57. Structural and design reports were not available for the D603 bridge and therefore reference could not be made to those. The assessment of existing design and structural conditions is important in order to provide detailed information regarding the nature of work required (for instance complete replacement) or to assess the level of impact, such as to historical landmarks or liveability (Ohio Department of Transportation (ODOT), 2017).

Additionally, infrastructure master plans were consulted to enable integration of proposed facilities within existing infrastructure. Transport master plans, which contain network and public transit system development plans, traffic control and transport demand management schemes, institutional and funding frameworks, best land uses as well as design guidelines, ensure sustainability of transportation infrastructure systems in terms of congestion, accident and travel demand management (DOT National Transport Master Plan, 2009). Reference to infrastructure master plans in turn improves service quality. Integration of existing transport routes with the LRT system in Addis Ababa was critical to reducing travel times and costs and to improving the overall connectivity of the network (Sabatino 2017).

International examples were referred to in the feasibility studies for the Gautrain and BRT projects. Benchmarking from international samples is critical given complexities of large-scale infrastructure projects. Adhering to quality standards when selecting the right investment targets for infrastructure is important for green-field infrastructure (Wiener, 2014:5). This is because investors are wary of the success of planned projects. They therefore desire that potential investment risks such as inflation, borrowing as well as political, social and environmental risks are identified and mitigations put in place to extirpate concerns and bottlenecks as much as possible. Removing greenfield bottlenecks improves credit quality and investment confidence as well as reduces transaction and running costs (Wiener, 2014). Therefore, benchmarking long-term financial performance from international best practices improves the efficiency and success of infrastructure projects (Ehlers, 2014).

Information from the public and private sectors, manufactures and suppliers as well as existing tendered rates were important references on some of the projects. Existing market studies and records of rates are important to compare cost estimates (Agbo *et al.*, 2017). The necessary data, which are obtainable through desk research, examination of country statistical data, international data, public and private sector consultations, are useful (Agbo *et al.*, 2017).

Further, regulatory documents were also referred to especially with regard to environmental dimensions of the projects. Policy instruments and guidelines are applied in feasibility, environmental impact assessment and environmental licensing (Bracarense *et al.*, 2016:306). Other context-specific factors such as rainfall data, drainage and flooding risks as well as household income surveys were referred to in order to further establish factors that will affect the performance of the project in the operational stage (Wiener, 2014).

5.4.2.4 Criteria factors considered

Environmental factors

Environmental features and compliance with regulations were considered in the feasibility studies of seven of the projects. Consideration of environmental impacts of proposed projects is essential in order to develop and put in place mitigation measures for possible externalities (Mukherjee and Roy, 2015). The compliance with environmental regulations with regard to preservation of natural spaces, flora and fauna is an important consideration in feasibility studies (Brown *et al.*, 2015).

Socio-economic environment

The socio-economic environment, which has to do with the benefits accruing from the proposed development (including comfort, benefits, convenience, vehicle/transport cost and travel time savings) as well as impact on the community concerned, in terms of heritage preservation and QOL were important factors considered in the feasibility studies undertaken for five of the projects (City Deep, Gautrain, N12, D1027 and D603) (Tsimplokoukoutt *et al.*, 2012; Jacobson *et al.*, 2013). Other costs such as tolls and fare charges, park-and-ride possibilities and charges, as well as alternative modes of travel were considered (Graham and van Niekerk, 2014).

Physical infrastructure factors

Further, technical factors such as structural quality and design, geological materials, drainage were considered important. Performance and reliability of transportation infrastructure is a concern and thus in terms of long-lasting potential of the physical infrastructure, structural and design elements are incorporated in feasibility studies (Friedrich and Timol, 2011; Twerefou *et al.*, 2015). Likewise, the state or condition of the existing infrastructure is an important consideration in feasibility studies, to ensure that the required improvements (replacement or rehabilitation) are planned (Hyari and Kandil, 2009).

Institutional frameworks

Further, procurement and funding models were considered on four of the projects (Gautrain, N12, K46 and K57). These projects include especially those that involved private investors or developers. Reaching a sound understanding of financial structures/frameworks, as well as the roles of the actors, sources of finance, and different institutional investors is critical at the feasibility stage projects (Wiener, 2014; OECD, 2017). Institutional frameworks, finance risks (risk profile including political risk, inflation and revenue risks), market forecasts, as well as return on financial channels and investment plan/strategy assessments (procurement and management) have to be considered in order to deliver financially sustainable infrastructure (Siemiatycki, 2010; Tsimplokoukoutt *et al.*, 2012).

Additionally, consideration of institutional frameworks hedges against who is responsible for maintenance and operations, taking into account the full costs of the transport system so that strategies can be put in place to internalise these costs including transaction and running costs, throughout its life cycle, which was not done on the BRT projects and thus has resulted in heavy dependence on government subsidies to operate (Rietveld and Stough, 2006:109).

In addition, attention to institutional framework assists in identification of investment risks, as well as government support and championship of the project (as was the case on the Gautrain project), improves efficiency and thus ensuring sustainability at the operational stage (Glaister *et al.*, 2010; Siemiatycki, 2010; Byaruhanga and Basheka, 2017). Political support from the government (as was done in the case of the Gautrain) ensures sustainability of the project (Glaister *et al.*, 2010). The need for strong and consistent political support was also emphasised in the BRT projects as government went ahead to build despite strong opposition from the taxi industry operators (Allen, 2013).

Further, a favourable institutional environment also ensures that there is coordination of efforts, delineation of roles/responsibilities (to parties best equipped to handle technical and managerial aspects) as well as consistent and reliable governance structures, which are essential conditions for sustainable transport systems (Glaister *et al.*, 2010; Quium, 2014). Governance dimensions of infrastructure investment need to be considered since they could affect the financial performance of projects. Regulatory changes can affect the performance of infrastructure projects (Brown *et al.*, 2006; Berg, 2009).

Costs

Associated costs of the project with regard to design requirements, construction, transaction, as well as running costs during the operational stage was an important consideration on the projects (Wiener, 2014). The operational life of projects is an important element in project feasibility studies of the projects as it ensures the financial and physical infrastructure sustainability aspects are taken care of at the initial stage. Moreover, affordability relative to transaction and running costs as well as government subsidy support was considered crucial as was the case on the Gautrain project. On the other hand, costs and affordability was related to ability of the end-users to pay, with an assessment of the household income such as on the BRT projects.

Traffic demand

Traffic demand was considered in relation to revenue accruing to investors. Traffic demand is an aspect of financial analysis that influences the rate of return to investment, based on the level of usage of the facilities. Traffic demand was also considered in order to gauge the ability of existing infrastructure to support current traffic conditions as was the case on the N12 and K46 projects.

Safety and security

Importantly, safety and security were considered on the projects. The concept of safety and security plays an important role in transport planning (Hyari and Kandil, 2009). Safety is associated with risk (Gromule *et al.*, 2017:148). Passengers must be satisfied that they will be safe; otherwise they would not travel. Providing safe transport networks at the planning stage is essential in order to ensure that accidents and fatalities are minimal during the operational stage. For instance, an assessment of site and locality characteristics and consideration of the possibility of providing a well-designed and separate slow zone and designated and formalised sidewalks ensures that users (motorised and non-motorised) are safe (World Bank, 2000; Pojani and Stead, 2015).

Security is related to uncertainty and confidence in the use of a particular mode of transport (Gromule *et al.*, 2017:148). Security considerations include putting systems in place for safety management and response to incidents of crime. Not having a plan to ensure pedestrian and road safety (walkways, and traffic signals), hampers the Addis Ababa LRT project's development goals and limits the effectiveness of the system (Sabatini, 2017:2). Hence, in order to maintain high performance in transportation safety, seamless coordination of activities and direct funding towards the highest safety priorities among multiple partners are required and these should be recognised and identified during the feasibility studies (FHWA, 2006).

Existing land uses

Land use patterns were considered because it is linked with demand for mobility in terms of travel generation, behaviours and schedule (FHWA, 2006:50). For instance, a residential land use has a pattern of movement structured in the morning and afternoon and mainly between home and work. Unsurprisingly, the management of the Gautrain project have considered originators and destinations in demand modeling to identify and plan for the travel patterns. Further, in relation to this, proximity to land uses and walking distances are important considerations since it is related to human needs, as indicated by the points of interest in Maslow's pyramid of human needs. (Chatziioannou and Alvarez-Icaza, 2017:8).

In summary, good quality project feasibility studies entail specialist studies, involve experts and stakeholders concerned, make reference to existing data and benchmark against best practices in order to identify preferred alternatives. They contain sufficient information, inclusively considering a plethora of factors in order to enable reliable decision making based on information provided (ODOT, 2017). The factors considered in feasibility studies include technical options analysis, financial appraisal, socio-economic appraisal, environmental impact assessment and other specialist studies (Mukherjee and Roy, 2017). Feasibility studies include site assessment, context-specific aspects (such as drainage and flooding risks), preliminary design considerations, cost estimates, existing conditions and capability of existing networks to meet infrastructure demands, demand forecasts, stakeholder engagements, and project coordination and championship as well as financial analysis (entailing costs, revenues accruing to the investors based on demand forecasts, rate of return, transaction costs and subsidies from government, risks) (Hyari and Kandil, 2009; Wiener, 2014; Mukherjee and Roy, 2017).

5.5 FINDINGS ON PROJECT PERFORMANCE

The findings on the performance of the projects are presented in this section. The projects are first analysed case-by-case and thereafter, across the cases in comparison.

5.5.1 Case-by-case analysis: Project performance

5.5.1.1 Case study 1 – The City Deep freight hub

When asked about the performance of the City Deep projects, based on the variables identified from literature review, a respondent informed:

"No complaints… there's accessibility even to the disabled (universal access) …traffic flow is okay, peak hours, there's traffic because remember all cars seem to be on the roads"

In terms of safety within the area, and the effectiveness of safety management programs, the respondent replied:

"Yes, there are speed limits on the route, traffic camera, traffic lights, parking bays for trucks, JMPD patrol along the roads"

On the value-add relating to new business opportunities in the area, the response was that there are new business ventures in the area as a result of the upgrade. In addition, environmental elements were construed with regard to the performance of the projects, as suggested in the following statements:

"No pollution now…. environmental control is ensured by the National Environmental Management Act (NEMA)… the natural environment is maintained by the CoJ satisfactorily…the transport furniture blends with the environment, …yes… the railing, markings, bus stop, stop signs, height restrictions (on the bridges).

Further, with regard to quality of the infrastructure and frequency of maintenance:

… condition is fine…. the road is able to carry future traffic…. congestion is bearable …the projects can withstand common weather conditions, rain, heat, flooding, but you know nature…."

Regarding institutional factors, the respondent informed thus:

"JRA is managing and capable …with regard to this project, there's no room for private investors, because it is owned by the JRA…. the communities are involved in maintenance…. I'll say

maintenance but you have to go through the procurement process, so basically, they will hire the local contractors that will maintain the grass cutting and cleanliness…"

In summary, the performance of the City Deep Hub projects in terms of accessibility, mobility, safety and security, environmental management and compliance, as well as the quality, capacity and condition of the infrastructure, is acceptable. In addition, new business ventures have developed in the vicinity, and users are satisfied.

5.5.1.2 Case study 2 – The Gautrain

Performance for the Gautrain project is actually assessed in terms of the long-lasting nature of the project and basically based on the twenty-five performance items which the GMA monitors, as informed by one of the respondents: *"… we're monitoring about 25-line items for the performance of the system…"*

The 25 items are grouped into (GMA, 2018):

- operational service (including train service availability and punctuality on schedule, as well as overcrowding management);
- feeder and distribution service (punctuality, availability and vehicle age);
- customer feedback (including timetable availability, call centre availability, availability of access control, real time information availability as well as passenger satisfaction and complaints);
- security (including physical security of passengers as well as their property); and
- cleanliness and damage repair (including train set condition as well as train and station cleanliness).

Recent performance assessment of the system indicates that it is performing better than projected on all variables including availability, punctuality, condition, cleanliness, safety, accessibility, satisfaction, demand, and so on. The Gautrain project is currently producing a highly impressive 99.67% service reliability, consistently outperforming its benchmark (KPMG, 2014).

Commenting on availability and reliability of the service, one of the respondents stated thus:
"…the differentiation of the Gautrain from any other kind of model was the kind of service we're offering …the level of reliability we're offering…like right now…its' up to the freeway what it does…if an accident occurs, you are stuck there….so predictability of trips is not there …we

guarantee you that if we took you from Hatfield, we will have you at Park in 42 minutes. And that we still guarantee today…… it has to be value for money because in essence if you look at it and if you had to compare driving your own car to using the system then the balance ends up being about how much time are you going to waste sitting in traffic. At the moment, it takes an hour and half for you to come to Hatfield into the city centre at peak hour and if anything happens, it takes about 2 or 2 and half hours to get into the city centre…if you value your time, that is important…."

On safety and security and effectiveness of safety management systems, respectively, other respondents proffered:

"Safety and security and passengers' property… we want to be sure that when you use the Gautrain. Your laptop is not going to disappear and you're not going to sit with a life or death and over the years. So on occasion there might be one or two incidents that pushes us in the red for a very short period of time but I think in the main, the performance of the system has been consistently above its targets…."

"The sort of thing that has been done is the whole system has been designed to be safe. Nobody can walk all the way unto the platform without going through the gates. As soon as something substandard, it is resolved, any weakness that could result in people getting illegally into the system can be dealt with. The next thing is the CCTV (closed circuit television) *cameras in all the stations, and in the corridors. So as the trains are running if for example, anyone tries to cross the fence between here and where the depot is, we have to see at some point when somebody is jumping the fence with our cameras. It looks up and down and sideways and then there are on-board cameras in the trains themselves. The trains are also equipped with cameras. It gives us some view of what's happening in the trains. The side fencing is the fact that access control is…you have to have a valid card to tap in, the gate doesn't just open because you stand in front of it, all of this contributes… By making sure that everyone in the system gets to pay is protecting the other passengers because you can't just come in and enter into the system."*

On the demand/ridership:

"The demand has grown exponentially …we have had to add about 200 bays for parking to accommodate people that were not able to use the trains because of parking facilities."

On affordability:

"*People that are using the train, they don't complain about affordability, but obviously the system was designed to move people from using their cars to using public transport, so if you're talking to LSM of people that have cars…."*

On users' satisfaction:

"*The users are satisfied. In our net promoters' call …the marketing research that we do….the question we ask is not how satisfied are you as a user….it's 'would you be willing to recommend the mode to someone else as a user'…96% of the people are willing to recommend the service to another and that is what is important… this is measured on a monthly basis…sometimes it goes down…it doesn't really go that far down…but it picks up again quite quickly"*

On the cleanliness of the system:

"The system is clean, the trains are clean …we have other rules that are not normally there like you can't eat on the train, which helps with the cleaning…. If people don't eat there then they don't litter…then you end up with a system that is clean, so the rules matter…"

On the environmental impact, respondents stated:

"The system uses regenerative breaking….the power generated by a slowing train is distributed back into the grid, so the train behind ramping up, takes up the power…that way we are reducing cost"

"We also have community projects as well as water saving methodology across the project…… at the time of feasibility, the cost of renewable energy was massive. So we went the traditional route of using coal power stations to provide power. …today in 2018, there's so much happening in terms of energy and water savings. So we are embarking on a S drive, to put up PV solar at our depot and as far as our stations, all the new stations will be powered completely by solar power."

On sufficiency of cash flow:

"…the farebox currently covers our operating costs…it far covers the cost of operating the system.it is sufficient in that manner … obviously as the province of Gauteng, there is some money that is being paid as well to cover whatever was agreed in the contract. So that's what it is."

On maintenance frequency:

"Our call log is quite low…our general call outs…for maintenance…are quite low" and the number of service disruptive and damaging call outs to the system matter…our service disruptive calls are very low compared to other systems around the world…These include when some or all trains are cancelled or delayed of up to 6 minutes…"

Further, the value-add attributed to the Gautrain was expressed as sustainable in terms of the economic and quality of life impacts. In particular, the property values of retail, office, industrial and residential space as well as economic activity sustained as a result of the additional development due to the existence of the Gautrain project.

Other direct and indirect impacts, including time savings and thus increased productivity levels, reduced congestion, and reduction in greenhouse gas emissions as well as increased demand, increase in business activity and property developments around the stations, which have indirectly created jobs and increased household income were revealed (KPMG, 2014). Specifically, there is:

- Increased property value of R12.9 billion;
- Increased employment: The development of residential properties and businesses around the stations sustained about 98,000 jobs in Gauteng in 2013, representing about 2% of the total employment in the Province that year;
- Reduced total cost resulting from fatal accidents by at least R17 million (April 2013 to March 2014). It is estimated that the Gautrain avoids between 13 to 81 fatal accidents and between 14 and 93 fatalities per year based on the assumption of percentage of accidents that occur on the Pretoria- Johannesburg corridor.
- Reduced number of cars on the road, 21,300 less cars daily, resulting in reduction in accidents.
- Reduction in Gauteng's carbon footprint by about 52% per trip (KPMG, 2014).

However, one of the respondents informed that concerns existed about the competition which the Gautrain faces in terms of the uber ridership, as stated thus:

"In that sense (demand)*, it is performing quite well, but with the uber destructive technology, in the sense that the train doesn't cover the last how many miles of the journey, you have to take another bus or taxi to get to the station, whereas with uber you can get to where you're going …we*

have experienced drop in passenger numbers in recent years …so as a result of more convenience with uber and of course the commotion with uber and taxis around the stations, but I think it is still performing better than expected."

In summary, the above suggests that transport projects can be influenced by alternative modes of transport (competition), which should be considered even during the planning stage, in terms of factors that could affect the sustainability of the project (when proposed). Other factors considered are demand, affordability or pricing, and revenue accruable during the operational stage.

Other factors considered in performance measurement are value-add or benefits (in terms of employment, safety, and property value appreciation), availability and punctuality, cleanliness, convenience, maintenance frequency, security, user satisfaction, environmental impact, demand, quality of service (operations) as well as that of the trains.

5.5.1.3 Case study 3 – The N12 (P186/1)

The performance of the N12 road project is satisfactory, as confirmed in the following statements regarding various performance variables including condition of the infrastructure, users' satisfaction, and environmental factors:

"The quality is good, the maintenance department in Krugersdorp maintains well…there are no complaints with quality…we manage the targets…jobs and new businesses were created….safety measures include the fencing (median) to avoid reckless driving… we do the auditing reports to check environmental compliance, no hazards… people are generally satisfied, traffic flow is acceptable… no complaints about pollution."

Therefore, the N12 road can be deemed to be performing well within the four years after its improvement in phase 1.

5.5.1.4 Case study 4 – The D1027 (Cedar Road)

The performance of the D1027 (Cedar road) was assessed based on its capacity to accommodate traffic demand experienced on the road. The traffic is as expected, and the road is capable of accommodating the traffic, as captured in a respondent's statement: *"It (the road) is capable of accommodating existing traffic."*

In addition, it was found that road users were satisfied and happy with benefits accruing for the use of the road such as travelling time reduction and savings in fuel costs. These can be deciphered from the following:

"*…The economic benefits, job creation…there is development along the route … the road users, they are happy because now the travelling time decreases, and they save costs on fuel because the road is good and there's no potholes anymore…. because they are able to travel faster on the upgraded smooth roads and be more productive at work"*

Further, with regard to private sector involvement, there is room for more investors. The partnership contract, which clearly states who is responsible for maintenance, is also being followed, as informed by a respondent: "*The GPDRT is responsible for the maintenance. The private developer was only responsible for putting the money."*

On the participation of the community in operations and maintenance, the response was in the affirmative: *"Yes… they are involved, that area is DA-governed … now they are involved in the follow up."*

Therefore, the performance of the D1027 (Cedar road) at present can be deemed to be satisfactory. The traffic capacity and quality of the infrastructure is being maintained. The demand is as expected, and user benefits are also being experienced.

5.5.1.5 Case study 5 – The K46

The performance of the K46 road was assessed with regard to satisfaction with the services and travel time savings (plus distances to major land uses), ridership, comfort, time, accessibility. In addition, environmental impact with regard to noise pollution is assessed. According to one of the respondents:

"Environmental impact is the noise levels, for the roads; for public transport, not so much. It is dealt with in the EIA, but we don't really go out and do an after-study. It is quite strange…. of course, we have a EIA, it's not about improvement, but how much is it calculated…I know the only one that was really done was on sound or noise levels before and after, so we need to do the studies"

On whether there was room for private investors, the respondent answered:

"If there's a partnership with the private sector, whenever we are upgrading the road, we look along the whole corridors if there are other developers there that we need that can contribute, but normally they've got a wait and see attitude and what we do, we build into their doorstep and leave it there."

In summary, the performance of the K46 is continually being sustained being a provincial road and major highway linking other important roads. There is room for private sector participation. The partnerships are however not invited in most cases; they usually occur by virtue of location and proximity of a private developer.

5.5.1.6 Case study 6 – The BRTs

The first review of the CoT BRT revealed that the BRT faced challenges that threaten its sustainability. These include low ridership, expensive stations and high costs of running closed stations, services relocation and operating feeders, legal issues, stakeholder engagement, land expropriation, slow rate of township infiltration, ongoing competition with the taxi industry, and unreliable detailed demand modeling (CoT, 2016). However, the BRT system is affordable, reliable, provides a clean quality transport service for commuters; has bus drivers and taxi drivers are in formalised employment systems and has improved the environment by using energy-efficient and green buses (Goondiwala, 2014). Passengers are safer. It is estimated that the accident rate is 4 per 100,000km travelled, which is lower than the CBD accident level due to traffic and pedestrian densities, at 12 per 100,000km (Goondiwala, 2014:18). These views were supported by respondents' statements on various aspects:

On safety, the respondents stated:

"It (safety) *is one of the selling points. People walking towards the BRTs are still in the normal environment, but once they are on the BRT station, the security there, our cameras, and the vehicles are supposed to be safer from driving techniques and behaviour that one can say is not good, accidents and things like that…"*

"As part of the agreement that we signed by the taxi operators, operating the BRT system, we have automated, urban traffic control …we can be able to draw a report regarding the behaviour of the driver in terms of breaking and so on. And if there was an accident, we're able to see what happened because there are cameras …so they are controlled …"

On ridership and revenue accruing from demand, revenue from ticket sales range from R4.3 to R6.5 million per month (Goondiwala, 2014). However, this is not acceptable. Ridership or demand for the services is not great (Venter, 2017). This can also be construed from a respondent's statement:

"… the systems are not getting the passenger volumes that they thought they would be getting…you must first have the passenger volumes on the route, the more people pay, the less subsidies you would need, so they can't be able to get the passengers off the route"

The reason for the shortage of passengers for the route appears to be attributable to the densities in urban cities in South Africa, as suggested by the respondent's statements:

"The more fundamental issue here is that our urban densities are very low. So it's a structural issue that these BRTs are not selling. If you look at Sao Paulo as a city of 22 million people with high rise buildings everywhere and you have these BRTs around there, they can operate without subsidies, it's possible and they sell at 6,7 times a day. We haven't got urban densities, we haven't got passenger volumes etc….but the fare is quite low as well, so if you have more passengers, they can increase the revenue."

Thus, in addition to the low fares and intermediate ridership, the BRT systems are expensive to operate since they are heavily subsidized and non-profitable, and this is a major concern among stakeholders:

"None of the BRTs are making money"

"…in general, if you look at the cost of the BRTs and the conventional buses and how much we're already spending on the BRTs which is 26 billion per year, the value for money proposition should be questioned, whether we should go ahead…a major review, for alternative ways of the same type of services but a much lower cost than what we have now….."

Further, creating a stakeholder-involved operating system with the taxi industry was desired. This is important to ensure future BRT success (Goondiwala, 2014:19). However, currently, it appears that this is still being negotiated twelve years down the line.

"The other problems obviously were that it was conceptualised that the taxis on the routes will actually become the operators, for the drivers to be part of the drivers of the BRT system, and there's supposed to be no intermodal competition from the taxis, but they have not succeeded in getting the taxis off these routes. Many of the passengers in the taxis ought actually to be on the BRT system based on conceptualisation but to enforce that is difficult."

On the part of the users' satisfaction, there are complaints regarding travel time with the use of the Rea Vaya, as informed by a user in Johannesburg, albeit it is safer than using regular taxis.

"The Rea Vaya is time-consuming…it takes like 2 and half hours to get home (Soweto) for school (UJ)…when it gets to Thokoza park, I have to wait and then take another taxi…local buses, to get home…although it's safe, but time-consuming…."

As a result of the lack of comprehensive studies at the initial stage of the BRT system, a subsequent review of strategies was done in 2014 to incorporate factors presented in Figure 5.3 and ensure long term sustainability of the system. In addition, facilities are intended to be convenient (offering the advantage of directness to key destinations); a*ccessible* (providing continuity of networks linking origins with destinations; s*afe* (separation of modes and avoidance of risk of conflicts or collusion); c*omfortable* (quality standards, accommodating mobility-impaired and disabled passengers, children, pushchairs, the elderly; and a*ttractive* (catering for people to stop, rest, chat, and window shop in aesthetically pleasing surroundings).

Cost	Planning and Management	Design	Performance	Impacts
• Capital Cost • Operating Cost • Planning Cost	• Planning and implementation time • Management and administration	• Design Scalability • Flexibility • Diversity versus homogeneity	• Capacity • Travel time/ speed • Service frequency • Reliability • Comfort • Safety • Customer service • Image and perception	• Economic impacts • Social impacts • Environmental impacts • Urban impacts

Figure 5.3: Factors considered in *A Re Yeng* (Tshwane BRT) review (CoT, 2016:2)

In summary, the performance of the BRTs was found to be dismal. The value for money hoped for when the BRTs were rolled out was not being achieved. This underlies the importance of adequate and accurate feasibility studies to ensure that all possible factors which could affect the sustainable performance of such green-field projects are incorporated and given considerable attention. By so doing, problems can be anticipated, and mechanisms put in place to ensure that the desired performance is sustained.

5.5.1.7 Case study 7 – The Tolwane Bridge – D603

The Tolwane Bridge project, which has just been completed, was intended to improve capacity (structural) and ability to accommodate traffic, improve safety of users, enhance aesthetics and reduce travel time. Although information on the current performance of the project was not available at the time of conducting this study, the project was included due to its unique characteristics and availability of rich data on the feasibility studies procedure, structures and criteria factors. Nonetheless, the importance of safety and capacity of the project were emphasised by the project manager interviewed on the project.

5.5.1.8 Case study 8 – The K57 (R82) (Phase 1)

The main objective of the project was to upgrade the road and improve performance in terms of safety and capacity. The performance of the K57 (R82) road was therefore assessed in terms of traffic congestion reduction and accessibility. In addition, road user socio-economic benefits including safety as well as travel time and fuel cost savings were reported (GPDRT, 2016). The furniture also blended with the environment and road markings provide an aesthetically desirable outlook as reported.

The above section presented discourse on the performance of the eight projects studies, respectively. These findings are summarised in Table 5.4. The project performance findings are further discussed comparatively in the succeeding section.

Table 5.4: Summary of findings on performance of the projects

S/No.	Project (case)	Findings on project performance
1	City Deep freight hub	Demand is as expected; New business ventures in the area; There is universal access; Safety & security mechanisms like speed limit control, traffic lights, cameras, JMPD patrol are in place & effective; Traffic flow is acceptable, heavier at peak hours; The National Environmental Management Act (NEMA) guides environmental compliance effectively; The natural environment is being maintained by the COJ; Users' needs are satisfied; Quality of services and condition of infrastructure are good; Infrastructure is able to withstand adverse weather; Capacity is good, able to perform; Infrequent breakdowns
2	Gautrain	Operational service (including train service availability and punctuality on schedule, as well as overcrowding management); Feeder and distribution service (punctuality, availability and vehicle age); Customer feedback (including timetable availability, call centre availability, availability of access control, real time information availability as well as passenger satisfaction & complaints); Security (including physical security of passengers as well as their property); Cleanliness & damage repair (including train set condition; train & station cleanliness).
3	N12 (P186/1)	The quality is good (no complaints); People are generally satisfied; The maintenance department in Krugersdorp maintains well; they manage the targets, New jobs and businesses were created; Safety includes the fencing (median) to avoid reckless driving; Checking and auditing of environmental compliance (no hazards); Traffic flow is acceptable; No complaints about pollution
4	D1027 (Cedar Road)	Traffic capacity and quality of the infrastructure is being maintained; The demand is as expected; User benefits (travel time and fuel cost savings) are being experienced
5	K46	Satisfaction with the services (public transport); Comfort; Travel time savings (plus distances to major land uses); Ridership; Accessibility; Environmental impacts with regard to noise pollution; There is room for private investors
6	BRTS	Road user and economic benefits including mobility (including catering for the disabled) increased; Decrease in travelling time which translates to savings in fuel cost; Increased productivity due to reduced travelling time; Development opportunities along the route, jobs were created; Improvement in attractiveness of nearby tracts of land; Potential of the road to carry more vehicles.
7	D603 Bridge	Capacity (structural) and ability to accommodate traffic; Safety of users; Aesthetics; Travel time reduction
8	K57	Safety; Capacity; Traffic congestion reduction; Accessibility; Travel time and fuel cost savings; Furniture blends with the environment and road markings provide desirable outlook (aesthetics)

5.5.2 Cross-case analysis: Project performance

The findings on performance of the projects studied were analysed across the cases in comparison. The findings were presented in a matrix in Table 5.5. The table contains a comprehensive listing of all the elements found on which assessment of the performance of the projects was based in actuality. The table shows that socio-economic factors and the condition of infrastructure were the most frequently occurring and therefore important performance variables among the respondents. On the other hand, ridership and service quality were deemed to be less important, having been considered on only three and two of the projects, respectively. The performance of the projects viz-a-viz these identified variables, are further discussed with reference to relevant literature.

Table 5.5: Project performance: Cross-case analysis

S/No	Performance variables	Cases								
		City Deep hub	**Gautrain**	**N12**	**D1027**	**K46**	**BRTs**	**D603**	**K57**	**Total**
1	Socio-economic aspects (savings, travel time reduction, affordability, comfort; intermodal competition; value-add [property value & new businesses])	x	x		x	x	x	x	x	7
2	Condition of infrastructure (maintenance, cleanliness, aesthetics, resilience/structural quality, capacity)	x	x	x	x		x	x	x	7
3	Safety and security (frequency of accidents, effectiveness of management systems, perception of security)	x	x	x		x		x	x	6
4	Accessibility / congestion	x		x		x	x		x	5
5	Stakeholder satisfaction	x	x	x		x	x			5
6	Effectiveness of environmental protection programs / compliance	x	x	x			x	x		5
7	Ridership		x			x	x			3
8	Service quality / operational efficiency (predictability, reliability, response to complaints)		x				x			2

5.5.2.1 Socio-economic factors

On seven of the projects, socio-economic benefits accruing to a project were the basis of performance measurement. On the projects, there are travel time savings as people get to their destinations faster with improved quality of the network and in the case of the Gautrain project, provision of an additional and alternative means of public transport. In addition, value is generated as a result of transport infrastructure developments (McGaffin, 2011). The Gautrain project, for instance has created value in different forms including sprouting of new businesses as well as land and property value increments within the vicinity of the stations (Peacock, 2016; Lombard *et al.*, 2017).

On the BRTs, job creation is a reality. However, the intermodal competition between the BRTs and the private taxi industry operators is a concern and thus sustaining the systems is proving to be difficult (Venter and Hayes, 2017). Although, the comfort and speed of the BRTS is generally preferred to other modes like minibus-taxis, the travel distances are too long as reported, and this is because of apartheid spatial planning and low densities (Venter and Hayes, 2017).

Affordability was considered in terms of the costs, revenue accruing to the investors and the amount of government subsidies need to run the projects. The Gautrain project is currently sustaining itself on the current fares and revenue obtaining from the project. On the other, hand, the BRT is not. On the latter, planners expected that fare revenues will cover direct operating costs, but this is not the case currently. The fares are too low and the cost of operating and maintaining the BRT system is high. To raise revenue, The BRT system is heavily dependent on government subsidies and significant considerations are being made to redesign and improve its sustainability potentialities. Fares should be profitable relative to operating costs (De Gruyter *et al.*, 2017).

5.5.2.2 Condition of physical infrastructure

The condition of infrastructure with regard to cleanliness and maintenance (damage repair/condition of train set) was considered important on almost all the projects. The condition of infrastructure (maintained) reflects its sustainability. Infrastructure in good physical condition positively affects the quality of services and has a spill-over effect on the environmental consequences of its use. With regard to long-lasting potential of transportation infrastructure, the physical condition and structural strength are critical because the capacity of the network to bear existing and expected traffic depends on the quality (Upadhyaya *et al.*, 2014). In addition, poor quality infrastructure is detrimental to an investor as people will be willing to pay for its use (Alasad *et al.*, 2012; Pregnolato *et al.*, 2017).

5.5.2.3 Safety and security

On the projects, safety is concerned with occurrence of accidents on the routes, safety management systems which exist as well as the effectiveness of the programs (Karlaftis and Kepaptsoglou, 2012). Safety is priority and effort is being made to ensure that users of the transport infrastructure facilities are safe. For instance, safety and security mechanisms like speed limit control, traffic lights, cameras, JMPD patrol are in place on the City Deep hub project; security procedures and procedures (ensuring that passengers tag in and tag out and security officers patrol) at the Gautrain stations, and fencing (median) on the N12 project. These measures are important in order to

5.5.2.4 Accessibility and mobility

Accessibility and mobility were also considered important on the projects. On the BRTs, it was in terms of making sure that the disabled and elderly wee accommodated. Transportation system features' performance can be evaluated in terms of their ability to accommodate people with disabilities (Litman, 2016:36).

5.5.2.5 Stakeholder satisfaction

Stakeholder satisfaction was measured based on user feedback and complaints on the Gauteng projects. There are no complaints on the performance of the system. On the other projects, people were also generally satisfied as found. Satisfaction with transport infrastructure and its services is varied based on individual experience, comfort and convenience of rides, frequency and punctuality as well as satisfaction with the quality of the infrastructure (Redman *et al.*, 2013; Pavlina, 2015).

Satisfaction among partners was also considered relevant since the project owners have to be satisfied with the status quo and the private investors (in the cases of the Gautrain and BRTs, for instance) have to deliver on responsibilities allotted while trying to make profit at the same time. The project owners are satisfied with the performance of the Gautrain, while they are not on the BRTs. This is because on the Gautrain, a performance contract was precisely put in place to stipulate what was required of the parties and the desired outcomes during the operational stage (Levitt and Eriksson, 2016), which was not the case on the BRTs. Therefore, adherence to the contract and deliverables is achievable if the desired performance (on different established variables) is envisaged and this can only be done at the feasibility stage.

5.5.2.6 Environmental factors

Environmental aspect was viewed based on compliance with environmental regulations and preservation of natural landscape features. Monitoring and evaluation of the level of compliance with regulations such as NEMA is important (Karlaftis and Kepaptsoglou, 2012). Environmental sustainability of land area consumed by transport facilities is desirable as natural spaces and features should be preserved as much as possible (Ramani *et al.*, 2009; National Geographic, 2016).

5.5.2.7 Ridership

Based on passenger numbers, transporting more than 120,000 passengers (one-way trips) daily, it appears that the BRTs are doing well. However, fewer people than forecast are using the system and fare revenues are lower than expected. This has in turn resulted to the project initiators subsidising the system more than planned (Venter and Hayes, 2017). Ridership is influenced by the service quality and reflects the effectiveness of a transport system (De Gruyter *et al.*, 2017). Ridership profiles are important sustainability measures as they reflect those who are catered for and thus, reflect the level of universal mobility obtainable on transport projects (Litman, 2016).

5.5.2.8 Service quality

Service quality, which reflects the operational efficiency of projects includes reliability of the system in terms of travel time frequency, traveller expectations in terms of punctuality and user complaints (as with the Gautrain). It also includes response time to incidents and complaints, traveller information, congestion mitigation, management of traffic delay due to maintenance works and other emergency transportation operations (Haas *et al.*, 2009; Ramani *et al.*, 2009; Dhingra, 2011).

In sum, the performance of the projects studied, according to the interviewees and evidence from document analysis, were assessed based on socio-economic benefits, condition of physical infrastructure, safety and security, accessibility and mobility, stakeholder satisfaction, environmental compliance and preservation, ridership, and service quality. These factors were deemed important indicators of transportation infrastructure sustainability. On the Gautrain project, all the factors deemed important and the performance indicators reveal that the project is doing well, in fact, performing better than expected, especially on the ridership, which tends to be a key factor as it relates to other variables such as satisfaction, revenue and subsidies. It is notable that on the other projects, revenue was not an issue due to the fact that they did not involve private investors who may be partially interested in cash flow and profits. Some of the projects involved private developers, who were only contributors owing to the fact that the developments traversed through their properties and thus they became parties to the projects. In these cases, revenue was not a concern.

In the case of the BRTs, the system is not performing as well as expected on ridership as well as revenue. Inadequate processes followed to conduct a comprehensive feasibility study led to projects being heavily subsidised by the government. The fares are too low; demand is not as expected and therefore revenue or cash flow is not as projects at the beginning of the project. Consequently, the systems are being sustained by the government and the project could fail if the status quo remains. Moreover, the institutional framework is not favourable given the intermodal competition that exists with the taxi industry operators.

Therefore, feasibility studies have an impact on transportation infrastructure project performance as evinced in literature and case study findings. Hence, given the above discussion, a hypothesis was postulated as follows: *Feasibility studies have an influence on project performance.*

5.6 CHAPTER SUMMARY

The current chapter presented findings from the first (qualitative) phase of the study, conducted using document analysis and interviews. The purpose of the qualitative phase was to identify factors incorporated in the feasibility studies of transportation infrastructure projects and their performance. This phase of the study therefore focused on obtaining actual data from projects which were in the operational stage. Information obtained was based on the actual reports on the feasibility studies conducted at the time of planning the projects. Current performance or progress reports on the projects were also amassed from documents availed by the related agency. Concomitantly, professionals involved with the projects (during planning and/or operations) were also interviewed to establish information regarding the feasibility studies undertaken on the respective projects as well as their current performance. For each of the cases, the documents and transcribed interviews were analysed with the aid of the ATLAS-ti software to output themes (Appendix VI-A to VI-H) which were used to consolidate the preliminary framework, in relation to theoretical evidence.

The findings revealed that experts in multi-disciplinary fields were involved in the feasibility studies. Independent analysts were also consulted to review and audit the outcomes where necessary such as the City Deep project. The processes used in the feasibility studies entailed identification and assessment of alternatives to develop scenarios in order to decide on the most suitable option for development. Reference was made to historical data in terms of traffic counts, design and maintenance reports, infrastructure master plans, regulatory documents, information from manufacturer and suppliers, as well as contextual data. The criteria factors considered included traffic, safety and security, costs, existing land uses as well as environmental, socio-economic, physical, institutional, financial issues.

With regard to the performance of the projects studied, findings revealed that based on socio-economic benefits, condition of physical infrastructure, safety and security, accessibility and mobility, stakeholder satisfaction, environmental compliance and preservation, ridership, service quality, and affordability, the projects were generally performing as expected, except for the BRT systems.

Findings suggest that feasibility studies have an influence on projects' sustainable performance. In cases where feasibility study was inadequate and non-comprehensive, failure was evident. Extant literature also show that the quality of feasibility studies influences the performance of projects at the operational stage and may lead to project failure. To test this relationship, a refined conceptual model was developed based on findings from the literature review and the multi-case study phases. The succeeding chapter presents the process of development of the conceptualised model.

CHAPTER SIX

CONCEPTUAL FRAMEWORK

6.1 INTRODUCTION

Following from the qualitative research findings, with the absence of consensus on the factors, which impact on the quality of feasibility studies, and the influence of feasibility study outcomes on the sustainability of transportation infrastructure projects, the current chapter presents a discourse on the gap(s) identified from the literature synthesis and integration of the qualitative phase findings presented in the previous chapter. Subsequently, the conceptualised model developed from the integration of the findings from the literature distillation and qualitative phase of the study, is presented. Therefore, the current study adopts the views expressed in previous studies, as the theoretical foundation of the study, and brings them together in a model that depicts the relationships between the factors that influence the quality of feasibility studies and the subsequent performance of the transportation infrastructure projects.

6.2 INTEGRATION OF FINDINGS FROM LITERATURE REVIEW AND QUALITATIVE RESEARCH

A panoply of studies has shown that a plethora of factors influence the quality of feasibility studies and subsequently impact on the sustainable performance of projects while in operation. Studies such as Kim (2007), Flyberg *et al.* (2006), Hyari and Kandil (2009), Cantarelli *et al.* (2010), Jeon *et al.* (2010), Etemadnia and Abdelghany (2011), Welde and Odeck (2011), Grant *et al.* (2012), Karlaftis and Kepaptsouglou (2012), Nicolaisen *et al.* (2012), Stapledon (2012), Hassan *et al.* (2013), Al-Masaeid and Al-Omoush (2014), Jeerangsuwan *et al.* (2014), Flyvberg *et al.* (2009; 2011; 2014), Rudžianskaitė-Kvaraciejienė *et al.* (2015) and Litman (2016) concur that the quality of feasibility studies influences the outcome (sustainable performance) of transportation infrastructure projects and indicated factors that must be considered at the critical stage of feasibility studies.

The availability and source of data are important considerations in feasibility studies (Kim, 2007; Etemadnia and Abdelghany, 2011; Hassan *et al.*, 2013). Reference to historical data, for instance, is important where it is necessary to adequately predict future patterns and composition of traffic as well as develop scenarios to cater for potential growth. Moreover, reference to existing information on design and structural aspects was also considered important. However, high dependency on historical information only could be misleading, especially for traffic forecasts, considering the highly dynamic and stochastic nature of congested networks (Etemadnia and Abdelghany, 2011). This view that the nature of data used could be misleading was evident on the Gautrain project and the BRTs, as reported by the respondents (in Section 5.4). On these projects, reference to international best practices to benchmark future performance appeared to have different results. While the Gautrain project was performing better than expected based on the demand modeling used at the time of planning, which was benchmarked against international examples of high-speed rail transit in the UK, the same could not be said about the BRTs with low travel rates, albeit reference was made to international projects in Brazil. The difference between the two projects, however, lay in the amount of time allocated to the feasibility stage, as discussed in sub-section 5.4.2.1. This reflected that although reference to international best practices is important, adequate allocation of time to evaluate all possible influences on the project was not done on the BRTs, and this affected the project during the operational stage.

In relation to the nature of data used, the period of investigation considered (distance into the future for which a forecast is required) influences the outcome of feasibility studies (Flyvberg *et al.*, 2006; Hyari and Kandil, 2009). This is because using data from projects which have been in operation for only a year may be misleading since the performance of the project would not have stabilised and so data from such projects may be unreliable in predicting future levels of costs and/or benefits (Flyvberg *et al.*, 2006).

Further, inclusion of a wider variety of factors that influence sustainable performance of projects during operations is key in feasibility studies. Specification of the feasibility model to include a wide variety of project performance-influencing factors is important because clarity and detail will be evident and thus inaccuracy of forecasts will be reduced to the barest minimum since all elements which could potentially influence the project's performance in future are considered at the planning stage (Welde and Odeck, 2011; Grant *et al.*, 2012; Jeerangsuwan *et al.*, 2014;

Rudžianskaitė-Kvaraciejienė *et al.*, 2015). This was also supported in the findings on the Gautrain case, whereby a variety of output specifications were set out from the onset as reported in the feasibility study processes and methods (as presented in sub-section 5.4.1.2).

The methods employed during feasibility studies were also found to be important considerations in feasibility studies (Flyberg *et al.*, 2006; Etemadnia and Abdelghany, 2011; Al-Masaeid and Al-Omoush, 2014; Jeerangsuwan *et al.*, 2014). Using subjective or objective methods of predicting traffic scenarios, for instance, results in different margins of error with regard to congestion control and management during the operational stage. Further, a comparison of interactions and development of scenarios using methods such as system dynamics method in forecasting increases clarity and accuracy of results (Gajendran *et al.*, 2015).

Nicolaisen *et al.* (2012) and Flyvberg *et al.* (2014) opined that inadequate or incorrect forecasts are a result of delusions (psychological biases) or honest mistakes on one hand, and deceptions or strategic manipulations of information on the other hand. The importance of reducing or eliminating bias during feasibility studies was supported on the City Deep Freight Hub project, whereby it was revealed that the client audited and vetted the outcome of the feasibility studies (Section 5.4.1.1 and Tables 5.2 and 5.3).

With regard to the people involved during feasibility studies, project evaluators have an impact on the outcome (quality), wittingly or unwittingly. Findings from the interviews supported that expertise was crucial in ensuring that feasibility studies were well conducted and various aspects were considered. In addition, a wide array of specialists in different fields and the public were involved on the Gautrain project feasibility studies to ensure that expected outputs were incorporated as much as possible (Section 5.4.1.2).

In addition, the procedures followed in feasibility studies were considered to be important to achieve good quality outcomes as a lack of understanding of the basic underlying process involved in feasibility studies results in unreliable outcomes (Hyari and Kandil, 2009; Rosenthal *et al.*, 2015). The procedure followed to conduct feasibility studies is critical because errors could be introduced and this will affect the outcome. Consideration of the procedure followed also involves selection of a suitable method of evaluation based on the needs, scenarios and alternatives required (Hyari and Kandil, 2009).

In relation to the procedures followed, allocation of adequate time was considered critical. On the BRTs project, inadequate time allocation had resulted in the system being heavily subsidised by the government. Fares were too low, demand was not as expected, there was intermodal competition (as adequate time was not allowed for stakeholder consultation, as with the e-toll case as well) and therefore revenue was not as projected at the beginning. Adequate planning allows for identification of technical, economic, psychological, and political influences on project performance (Cantarelli *et al.*, 2010). Allocating enough resources in terms of time ensures validity of feasibility studies as it enables better decision-making with increased attention to all possible alternatives on which reliable recommendations and development of more appropriate means can be made (Hyari and Kandil, 2009; Cantarelli *et al.*, 2010). Unfortunately, decision-makers and investors many a time commit to ineffective courses of action much earlier in the decision-making process and this results in much lower cost estimations than those estimated at a later stage, as was the case on the BRT project (Canterrelli *et al.*, 2010). Nevertheless, a note of caution was sounded in Flyvbjerg *et al.* (2005) and Kennedy (2015), who opined that feasibility study outcomes could become obsolete if there are huge time lapses between construction life cycle phases, especially in the case of mega projects, which usually take a number of years to implement.

Therefore, while a plethora of studies acknowledged that a multitude of factors should be considered in feasibility studies for transportation infrastructure, the role of the people involved, the appraisal methods and data used, the criteria factors considered and procedures followed in ensuring that good quality feasibility studies are produced is not clear. This non-clarity is a problem because projects will continue to fail if attention is not given to who undertook the study and how it was done. It was therefore theorised that even with careful selection of an appropriate method of appraisal, as well as data and factors to incorporate in the project, transportation infrastructure feasibility studies will not be of a high quality if experts, auditors and stakeholders are not involved and the correct procedure of identifying and evaluating alternative options and strategies, is not followed. Feasibility studies are time-consuming and consist of multiple analyses carried out in sequence to screen alternatives based solely on the merits of the analysis, and involve multiple experts (Dey, 2001; Hyari and Kandil, 2009). This was the case with the Gautrain project, which was evidently performing as well, if not better, than expected as evinced from the qualitative research. Consequently, the present study conceptualised that transportation infrastructure feasibility study (TIFS) factors were related to the quality of feasibility studies in terms of who was involved and how the study was conducted, which in turn ultimately influences the sustainability of transportation projects.

Moreover, no study had statistically demonstrated the relationship between feasibility studies and project performance in this way. Glaister *et al.* (2010) explored the effect of procurement and financing strategies (including concessionaire selection, experience, technical strength and commitment, establishment of state-owned, special purpose company to construct, manage and operate; and involvement of development institutions) on the financial and operational sustainability of projects, but did not really reveal the relationship between the factors considered.

Likewise, Rudžianskaitė-Kvaraciejienė *et al.* (2015) focused on the effectiveness of PPP road projects and reported that factors which impact on the sustainability of projects should be included in feasibility studies. However, Rudžianskaitė-Kvaraciejienė *et al.*'s study did not demonstrate the extent of influence of the identified factors on the sustainability of projects. In addition, the study included only road infrastructure projects developed through PPPs and therefore might not be generalisable to other types of projects. Additionally, Alasad *et al.*'s studies (2012; 2013) focused on factors of transport demand and their interrelationships, which in turn influence the financial sustainability of projects, but did not reveal the extent of the interrelationships.

Further, the model proposed by Dey (2001) identified that technical, environmental, socio-economic and social factors are critical considerations at the feasibility stage if sustainability of infrastructure projects is to be attainable. Sustainability was described in terms of public acceptability, profitability and ultimately continuity of projects. Although Dey's study was conducted in the oil and gas sector, it is applicable to other sectors and projects whose operational stage covers their entire life span, such as the transport projects.

Moreover, models which had been proposed to measure transport infrastructure performance excluded some important sustainability aspects. The National Research Council (NRC) in their 1995 study on "Measuring and Improving Infrastructure Performance" established that efficiency, effectiveness and cost can comprehensively measure infrastructure performance (Oswald *et al.*, 2011). The NRC study was conducted among various stakeholders including operators, owners, builders, and neighbours of the infrastructure. However, the established measures did not take into account the lasting nature of the physical infrastructure as well as the financial sustainability of the project. Likewise, Oswald *et al.* (2011) identified aspects of transport performance relevant to various stakeholders, including business owners and user, and emphasised the importance of a focus on performance measures during decision-making to develop. However, the study focused on performance measurement and did not demonstrate relations with feasibility studies.

Consequently, since the relations between feasibility studies and sustainability of transportation infrastructure projects had not been previously investigated statistically, it was important to explore this critical upshot, with particular reference to the mediating role of people and procedures in delivering good quality feasibility studies. It was therefore conceptualised that it is possible to consider all the factors which might affect the project during the operational stage, including the criteria factors, methods of appraisal and data used in evaluation, but the questions of who was involved and how the feasibility study was conducted are critical if good quality feasibility studies are desired. If relevant people and procedures are not dedicated to the critical stage of feasibility studies, the chances that projects will deliver intended objectives in the expected life cycle is slim. The conceptual framework developed from the literature review and qualitative research findings (presented in the next section) was based on this premise.

6.3 TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDY MODEL

Based on the gaps and findings identified from the review of literature as well as results from the qualitative phase of the study, the current study developed a model of elements which could possibly influence the outcome of feasibility studies and subsequent performance of transportation infrastructure projects (Figure 6.1). Transportation infrastructure feasibility study (TIFS) factors (including appropriate methods used singly or in combination, availability and sources of data, people involved, procedures adopted as well as criteria factors) were related to the quality of feasibility studies (FQ), which in turn influence project sustainability (PS). Taking cognisance of transportation infrastructure feasibility study (TIFS) considerations could ensure sustainability of transportation infrastructure projects. The TIFS model could therefore be used as a tool to conduct feasibility studies in order to ensure sustainability of transportation infrastructure.

Four broad relationships were conceptualised and depicted in the hypothesised TIFS model. The relationships were in line with the objectives of the current study. These were as follows:

H1 – TIFS has a direct influence on FQ;

H2 – FQ has a direct influence on PS;

H3 - TIFS has a direct influence on PS; and

H4 – TIFS has an indirect influence on PS, with FQ as a mediating factor.

H5 – TIFS is a six-factor model comprising methods of appraisal, finance availability, planning data, user needs, local environment and strategic support.

The TIFS model was validated using the questionnaire results. The sub-models were presented hereunder and the validation results were presented in the succeeding chapter.

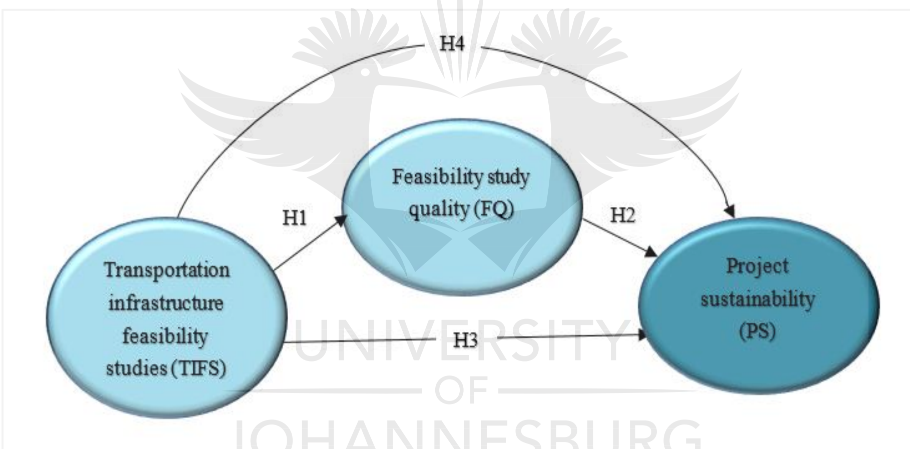


Figure 6.1: Conceptual model

6.3.1 Components of the conceptual framework

The measures or indicators of the constructs were expanded in this section as presented in figures and tables. The variables for each component are represented in Tables 6.1, 6.2 and 6.3, as well as the sub-model diagrams in Figures 6.1 and 6.2. The rectangles represent the measurable variables, whereas the ovals represent the latent variables. The dependent variables are so-called because their variance can be predicted or explained by one or more of the independent variables (Min and Mishra, 2010:113). Constructs (or latent variables) represent conceptual variables in statistical models, inferred from manifest variable (called indicators, items or measures) to enable empirical testing of hypotheses (Jarvis *et al.*, 2003). Indicators are observed or measured directly to represent some characteristics of the object under consideration (Schreiber *et al.*, 2006).

6.3.1.1 Transportation infrastructure feasibility studies (TIFS)

Feasibility study elements, the independent variables in this research, were conceptualised to be adequately measured by *data* (DA1 – DA8), *criteria factors* (CF1 - CF21), and *methods* (ME1 - ME9) (Figure 6.2 and Table 6.1).

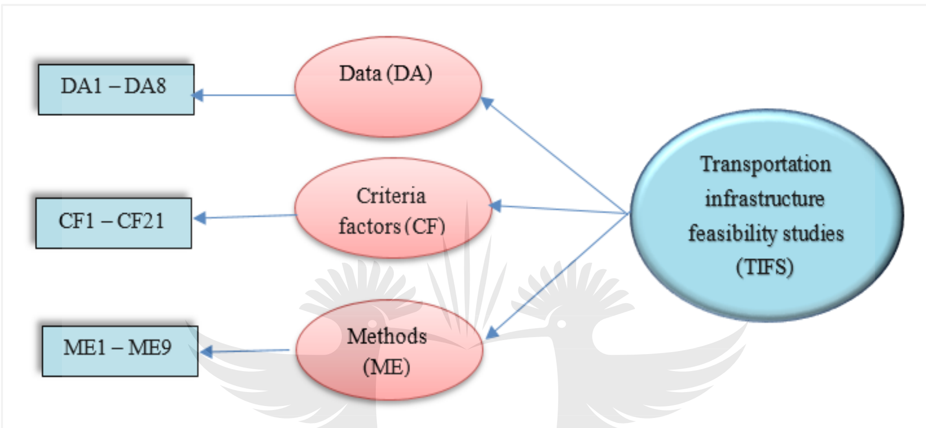


Figure 6.2: Transportation infrastructure feasibility study (TIFS) component of the model

Table 6.1: Feasibility study elements

S/No.	TIFS factors	Measures	Label
1	Planning data	Traffic data	DA1
		Existing design & structural reports, for upgrade projects	DA2
		Audit observations and performance reports, for upgrade projects	DA3
		International projects as examples	DA4
		Public records and manufacturers	DA5
		Existing financial and tender records	DA6
		Infrastructure development master plans	DA7
		Household income survey data	DA8
2	Feasibility criteria factors	User comfort during travel	CF1
		Convenience to users	CF2
		Preservation of cultural heritage	CF3
		Speed and travel time	CF4
		Travel costs for commuters	CF5
		User safety	CF6
		Proximity to user daily needs	CF7
		Accessibility to all, including the disabled	CF8
		Local conditions	CF9
		Structural capacity of existing infrastructure, for upgrade projects	CF10

Table 6.1 (cont'd.): Feasibility study elements

S/No.	TIFS factors	Measures	Label
		Condition of existing infrastructure was a major consideration, for upgrade projects	CF11
		Existing businesses/vendors	CF12
		Land use integration	CF13
		Sources of project finance	CF14
		Financial input from private investors	CF15
		Financial self-sustenance of the system	CF16
		Central Government's support of the project from start to finish	CF17
		Management capacity	CF18
		Life cycle cost of the system	CF19
		Stakeholders' interests and needs	CF20
		Competing transportation modes within the locality	CF21
3	Investment appraisal methods	Traffic growth analysis	ME1
		Best scenario outcome	ME2
		Multi-criteria analysis	ME3
		Costs and benefits analysis	ME4
		Site/location characteristics	ME5
		Design and scope requirements	ME6
		Financing alternatives relative to costs (financial)	ME7
		Rate of return on investment	ME8
		An environmental impact assessment	ME9

6.3.1.2 Feasibility study quality (FQ)

The quality of feasibility studies was theorised to be adequately measured by ten indicators related to the people involved and procedures undertaken. As stated earlier, some elements were added for the purpose of obtaining information regarding a related study on expertise. However, only the items related to the current study were included in this model, as presented in Table 6.2.

6.3.1.3 Project sustainability (PS)

With regard to the performance measures, which were the dependent variables in this study, twenty-eight variables, grouped into six factors, were observed to adequately measure sustainable performance of transportation infrastructure projects (Table 6.3). These included socio-economic environment (SE1 – SE8), financial factors (FI1 – FI3), condition of physical infrastructure (CI1 – CI4), safety and security (SS1 - SS5), stakeholder satisfaction (ST1 – ST5), and service quality (SQ1 – SQ3) as shown in Figure 6.3.

Table 6.2: Measures of feasibility study quality

S/No.	FQ factors	Feasibility study quality measures	Label
1	**People**	Experts in feasibility study conducted the study	FQ5
		All stakeholders were involved in the decision-making process	FQ8
		Involved independent specialists who had no interest in the project outcome to audit and review it	EX2
		Involved environmental specialists	EX3
		Involved professionals who eventually managed (are managing) the projects during the operational stage	EX4
2	**Processes**	Alternative solutions were identified for the project	FQ1
		The alternatives were sufficiently evaluated before a decision was made	FQ4
		Sufficient time was allowed to conduct the feasibility study	FQ6
		All possible risks to the project were clearly identified	FQ9
		Measures were recommended to manage identified risks	FQ10

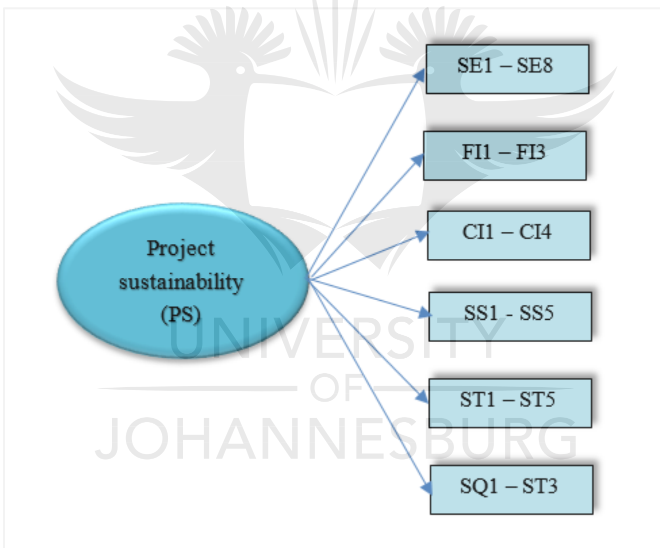


Figure 6.3: Project sustainability component of the model

6.4 CHAPTER SUMMARY

In this chapter, a conceptual model was theorised that transportation infrastructure feasibility studies (TIFS) had influence on the quality of feasibility studies (in terms of people and procedures) and ultimately, the sustainability of transportation projects. It was further theorised that TIFS could be directly or indirectly related to the sustainability of projects. Coupled with findings from the literature review and qualitative phase of the study, the factors related to these identified concepts were identified and related as theorised. The three factors of transportation infrastructure feasibility studies were collectively referred to as TIFS. The analysis of results from the questionnaire and the validation of the conceptual model were presented in the next chapter.

Table 6.3: Transport infrastructure sustainability measures

S/No.	Factors	Measures	Labels
1	Socio-economic environment	There are no complaints about travel times	SE1
		There are no complaints about user discomfort during travel	SE2
		There are no complaints about inconvenience during travel	SE3
		There is no competition between different modes of transport	SE4
		Property values have increased after the infrastructure was built	SE5
		New business ventures have developed after the infrastructure was built	SE6
		Infrastructure is accessible by all including the disabled and elderly	SE7
		Demand for the infrastructure services is as expected	SE8
2	Financial factors	Capital invested has been recovered	FI1
		There are no complaints about maintenance resources	FI2
		There are no complaints from investors about revenue	FI3
3	Condition of physical infrastructure	The infrastructure is in good condition	CI1
		There are no complaints about the cleanliness of the infrastructure	CI2
		There is no traffic overload	CI3
		The infrastructure, in its present condition, is able to withstand common adverse weather	CI4
4	Safety and security	Signage for safety is adequate	SS1
		Fencing (median) is in place for safety	SS2
		Security officers are visible	SS3
		Security cameras are in place	SS4
		Formalised sidewalks are in place for pedestrians	SS5
5	Stakeholder satisfaction	The needs of the stakeholders are satisfied	ST1
		Users are satisfied with pricing/charges	ST2
		There are no operational problems	ST3
		The actors are able to work in collaboration with other stakeholders	ST4
		There is clarity of responsibilities among partners	ST5
6	Service quality	Management responds quickly to user complaints about infrastructure services	SQ1
		Management responds quickly to user complaints about safety incidents	SQ2
		The infrastructure services (rides) are predictable	SQ3

CHAPTER SEVEN

QUANTITATIVE RESEARCH FINDINGS

7.1 INTRODUCTION

Following the presentation of the integration of the distilled evidence from the literature synthesis and the multi-case study findings, the conceptualised framework in Chapter six will be validated and tested in the current chapter. The quantitative phase of the study identified feasibility study elements which are predominant on the projects, the factors which influence the quality of feasibility studies, the extent of the influence as well as the impact of the factors on the performance of transportation infrastructure projects.

The descriptive and inferential statistics were presented. The descriptive results were first presented and conveyed in tables to achieve the objective GO1 of the study: establish critical transportation infrastructure feasibility study (TIFS) factors with regard to data used, criteria factors considered and methods used in the studies. Thereafter, the results of the exploratory factor analysis (EFA) and structural equation modelling (SEM) were presented in relation to objectives GO2 to GO4.

7.2 DESCRIPTIVE ANALYSIS RESULTS

Descriptive analysis was used to establish the predominant TIFS elements considered in feasibility studies. The findings on the feasibility study elements included the data used, criteria factors considered and methods adopted for the feasibility studies. The results displayed were the mean (M), standard deviation (SD), median (MD), 25% and 75% quartiles (Q1 and Q3), and interquartile range (IQR) values for each of the variables. The percentage responses were presented in Appendix VII.

7.2.1 Data used

Respondents were asked to indicate the extent to which they agreed or disagreed with statements regarding the data used during the feasibility study of the projects they were involved in. Table 7.1 showed that participants indicated most agreement (including strong agreements) with *traffic data*, which recorded the highest mean (M=4.13), with SD = 0.826; MD= 4.00 (4.00 – 5.00). The median value (4.00) indicated that 50% of the respondents were in agreement regarding the statement. The SD values were less than 1, indicating that the responses were closer to the mean. The interquartile range values of between 4.00 and 5.00 (IQR of 1) also supported that responses were not far from the median. These values seemed to suggest that the respondents had similar opinions regarding the statement that traffic data were used in the feasibility studies for the projects.

Infrastructure development master plans followed with M=4.04; SD=0.801; and MD = 4.00 (4.00 – 5.00). Similarly, the SD values less than 1 indicated unified opinions from respondents. The IQR of 1 indicated that the respondents were in agreement regarding the statement as the answers were mostly concentrated around the median.

On the other hand, *international projects as examples* (M=3.34; SD=1.197; MD=3.00 (2.00 – 4.00) and *household income survey data* (M=2.82; SD=1.195; MD=3.00 (2.00 – 4.00) ranked the least among the statements, suggesting that participants indicated most disagreements with these statements. Both the SD and MD values also indicated that the respondents tended to disagree on a wider range, with an IQR of 2 respectively.

Table 7.1: Findings on planning data used

Factor	Measures	Mean	SD	Median	Q1	Q3	IQR
Planning data	Traffic data	4.13	0.826	4.00	4.00	5.00	1.00
	Infrastructure development master plans	4.04	0.801	4.00	4.00	5.00	1.00
	Existing design and structural reports, for upgrade projects	3.98	0.818	4.00	4.00	5.00	1.00
	Audit observations and performance reports, for upgrade projects	3.82	0.840	4.00	3.00	4.00	1.00
	Existing financial and tender records	3.68	0.863	4.00	3.00	4.00	1.00
	Public records and manufacturers	3.67	0.905	4.00	3.00	4.00	1.00
	International projects as examples	3.34	1.197	3.00	2.00	4.00	2.00
	Household income survey data	2.82	1.195	3.00	2.00	4.00	2.00

7.2.2 Feasibility criteria factors

Respondents were asked to indicate the extent to which they agreed or disagreed with statements regarding factors on which assessments were based (criteria) during the feasibility studies. Table 7.2 indicated that respondents were in agreement with statements regarding *user safety, local* *conditions, condition of infrastructure, speed and travel time, stakeholders' interests and needs, land use integration, structural capacity of existing infrastructure, for upgrade projects, convenience to users, and management capacity.* These statements had mean scores of 4.00 and above, indicating that responses were mostly on the "agree" category. Further, all the median values for the above statements were also 4.0 indicating that 50% of the respondents were agreed to the statements. Al the IQR values for these nine statements also indicated that the respondents had similar opinions as the answers were within the range of agree (Q1=4.00) to strongly agree (Q3=5.00).

Table 7.2: Findings on feasibility criteria factors

Factor	Measures	Mean	SD	Median	Q1	Q3	IQR
Feasibility criteria factors	User safety	4.24	0.926	4	4	5	1
	Local conditions	4.15	0.805	4	4	5	1
	Condition of existing infrastructure, for upgrade projects	4.09	0.890	4	4	5	1
	Speed and travel time	4.08	0.913	4	4	5	1
	Stakeholders' interests and needs	4.08	0.768	4	4	5	1
	Land use integration	4.03	0.941	4	4	5	1
	Structural capacity of existing infrastructure, for upgrade projects	4.02	0.877	4	3	5	2
	Convenience to users	4.01	0.878	4	4	5	1
	Management capacity	4.00	0.865	4	4	5	1
	Central Government's support of the project from start to finish	3.98	0.935	4	4	5	1
	Life cycle cost of the system	3.97	0.980	4	3	5	2
	Accessibility to all, including the disabled	3.95	0.864	4	3	5	2
	User comfort during travel	3.92	0.978	4	3	5	2
	Sources of project finance	3.88	0.996	4	3	5	2
	Preservation of cultural heritage	3.85	0.912	4	3	4.75	1.75
	Proximity to user daily needs	3.82	0.998	4	3	4	1
	Travel costs for commuters	3.77	1.138	4	3	5	2
	Existing businesses/vendors	3.77	1.081	4	3	5	2
	Competing transportation modes within the locality	3.54	1.125	4	3	4	1
	Financial self-sustenance of the system	3.48	1.176	4	3	4	1
	Financial input from private investors	3.15	1.308	3	2	4	2

7.2.3 Investment appraisal methods used

Table 7.3 presents findings with regard to the methods used in feasibility studies. Respondents were asked to indicate the extent to which they agreed or disagreed with the statements. The table evinced that methods used mostly entailed design and scope requirements (M=4.21; SD=0.691; MD=4 (4 - 5), environmental impact assessments (M=4.15; SD=0.842; MD=4 (4 - 5), as well as cost and benefits analysis (M=4.13; SD=0.795; MD=4 (4 - 5). The least used methods or approaches appeared to be *financing alternatives relative to costs (financial)* (M=3.61; SD=1.068; MD=4 (3 – 4) and *rate of return on investment* (M=3.42; SD=1.185; MD=3 (3 – 4). The median value of 3 for the *rate of return on investment* statement indicated that responses were mostly concentrated on the "neutral" category, and the IQR value of 1 suggested common views among the respondents.

Table 7.3: Findings on investment appraisal methods used

Factor	Measures	Mean	SD	Median	Q1	Q3	IQR
Investment appraisal methods	Design and scope requirements	4.21	0.691	4	4	5	1
	An environmental impact assessment	4.15	0.842	4	4	5	1
	Costs and benefits analysis	4.13	0.795	4	4	5	1
	Site/location characteristics	4.11	0.774	4	4	5	1
	Best scenario outcome	4.02	0.804	4	4	5	1
	Traffic growth analysis	4.01	0.887	4	4	5	1
	Multi-criteria analysis	3.84	0.907	4	3	5	2
	Financing alternatives relative to costs (financial)	3.61	1.068	4	3	4	1
	Rate of return on investment	3.42	1.185	3	3	4	1

7.3 EXPLORATORY FACTOR ANALYSIS RESULTS

The conceptualised model was subjected to factor analysis using maximum likelihood factoring. Prior to factor analysis, the suitability of the data for factor analysis was assessed for assumptions for statistical input using tests for sampling adequacy and strength of correlation between measures. The results of the exploratory factor analysis were presented sequentially.

7.3.1 Transportation infrastructure feasibility study (TIFS)

Sampling adequacy was assessed for the TIFS measures, including data, criteria factors, and methods. The Kaiser-Meyer-Olkin (KMO) value for the measure of sampling adequacy was 0.824, exceeding the recommended value of 0.6, and the Bartlett's test of sphericity reached statistical significance at p = .000 (χ^2 (703) = 3520.135), indicating factorability (Appendix VIII-A). Inspection of the correlation matrix revealed the presence of many coefficients greater than 0.3, and all the variables correlated with at least one other variable, indicating suitability of data for factor analysis. The anti-image correlation matrix, with diagonals all above 0.5 (ranging from 0.604 to 0.931) also supported the factorability of the data set. The initial communality estimates all had values greater than 0.4 (Appendix VIII-B), and thus further indicating that the data was suitable for factor analysis.

Table 7.4: Results on TIFS sampling adequacy

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.824
Bartlett's Test of Sphericity	Approx. Chi-Square	3520.135
	df	703
	Sig.	.000

After extraction, the results revealed that nine factors had eigen values above 1 (12.48, 3.65, 2.99, 2.26, 1.76, 1.39, 1.22, 1.07, 1.04) and could be retained (Table 7.5). These nine factors contributed a total of 73.27% of the variance in the data set. An examination of the scree plot also supported that the nine common factors were above the breaking point, and could be retained for further analysis (Appendix VIII-C).

However, the communality estimates (Appendix VIII-B), after extraction showed that two of the items were below 0.4 and may have little influence in the data. These factors included DA7 (0.374) and DA8 (0.366). The pattern matrix (Table 7.6) was then examined to decipher how the items loaded on the nine common factors. Since the purpose of the EFA was to determine the minimum number of factors underlying the structure, correlations among items and items that did not load or had low loadings (below 0.4) on any of the extracted factors, the pattern matrix was inspected for such items (Matsunaga, 2010:101). Table 7.6 supported that some of the items, including DA7 and DA8, were indeed weak and may be removed. A decision was therefore made to delete the factors in order to improve the factor structure.

Table 7.5: Variance explained by TIFS measures

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	**12.477**	**32.834**	**32.834**
2	**3.652**	**9.611**	**42.446**
3	**2.986**	**7.859**	**50.305**
4	**2.264**	**5.959**	**56.264**
5	**1.762**	**4.636**	**60.900**
6	**1.394**	**3.669**	**64.569**
7	**1.220**	**3.211**	**67.780**
8	**1.071**	**2.818**	**70.598**
9	**1.014**	**2.667**	**73.265**
10	.903	2.377	75.642
11	.833	2.193	77.835
12	.780	2.052	79.887
13	.722	1.899	81.786
14	.673	1.771	83.557
15	.596	1.569	85.125
16	.547	1.438	86.564
17	.491	1.292	87.856
18	.456	1.199	89.055
19	.383	1.007	90.062
20	.374	.984	91.046
21	.357	.940	91.986
22	.330	.869	92.855
23	.298	.785	93.640
24	.280	.736	94.375
25	.270	.711	95.086
26	.252	.662	95.748
27	.242	.637	96.385
28	.213	.560	96.945
29	.199	.525	97.470
30	.179	.471	97.941
31	.143	.377	98.317
32	.136	.358	98.675
33	.120	.317	98.992
34	.107	.280	99.273
35	.086	.227	99.500
36	.075	.197	99.697
37	.062	.164	99.861
38	.053	.139	100.000

Values in bold contributed the most variance in the data set.

Table 7.6: Factor loading of TIFS measures – First run

	Factor								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
ME5	.916								
ME6	.895								
ME2	.846								
ME4	.728								
ME9	.725								
ME1	.654								
ME3	.519								
CF19	.319								
CF1		1.091							
CF2		1.059							
CF6		.671							
CF4		.533							
CF13		.411							
CF17		.367							
CF15			.933						
ME8			.830						
CF16			.742						
ME7			.697						
CF5		.423	.468						
CF14			.460						
DA6			.427				.346		
CF11				.925					
CF10				.810					
CF12				.496					
CF3				.337					
CF21					1.008				
CF20					.660				.391
CF18					.446				
CF7					.409				
CF8					.357				
DA2						.968			
DA3						.726			
DA1						.376			
DA5							.794		
DA7				.334			.334		
DA4								.655	
DA8					.303			.375	
CF9				.458					.514

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 11 iterations.

The items were deleted one by one, in the order presented in Table 7.7 and the rotation was rerun after each deletion. The results of the factor loadings after each deletion were presented in Appendix VIII-D to VIII-P). A total of fifteen items were removed according to the magnitude or strength of their loading as well as cross-loading after each run.

Table 7.7: Order of deletion of TIFS measures for repeated rotations

S/No.	Label	Measure	Factor loading informing decision to delete
1	DA8	Household income survey data	Lowest factor loading (0.366)
2	DA7	Infrastructure development master plans	Cross loading on three factors (0.386, -0.305 & 0.385)
3	ME9	An environmental impact assessment	Cross-loading on two factors (0.723 & -0.476).
4	DA5	Public records and manufacturers	Single item loading repeated
5	CF7	Proximity to user daily needs	Low loading (0.328)
6	CF8	Accessibility to all, including the disabled	Cross loading (0.355 & 0.323)
7	DA1	Traffic data	Repeated cross loading (0.352 & 0.367)
8	ME8	Rate of return on investment	Cross loading (0.357 & 0.658)
9	CF5	Travel costs for commuters	Cross loading (0.418 & 0.377)
10	CF17	Central Government's support of the project from start to finish	Low loading (0.325)
11	CF3	Preservation of cultural heritage	Low loading (0.339)
12	DA4	International projects as examples	Cross loading (-0.399 & 0.557)
13	CF9	Local conditions	Cross loading (0.478 & 0.479)
14	CF19	Life cycle cost of the system	Low loading (0.369)
15	CF13	Land use integration	Low loading (0.415)

After sixteen runs, the factor loadings improved, with six common factors (Table 7.8). This six-factor structure was observed to be acceptable, having item loadings well above 0.4 on the common factors. It is notable that the fifth factor had only two items loading on it. However, it was still considered acceptable because the items were related to existing data on which forecasts and projections can be made for the useful life of a project (Hyari and Kandil, 2009:68). Therefore, since audit and performance reports as well as existing structural reports are indispensable in feasibility studies, these were considered important and therefore retained.

Table 7.8: Factor loading of transportation infrastructure feasibility study measures - final

S/No.	Label	Measures	Factor					
			1	2	3	4	5	6
1	ME2	Best scenario outcome	.982					
2	ME5	Site/locational characteristics	.888					
3	ME6	Design and scope requirements	.780					
4	ME1	Traffic growth analysis	.771					
5	ME4	Costs and benefits analysis	.731					
6	ME3	Multi-criteria analysis	.707					
7	CF15	Financial input from private investors		.981				
8	CF16	Financial self-sustenance of the system		.847				
9	ME7	Financing alternatives relative to costs (financial)		.546				
10	DA6	Existing financial and tender records		.540				
11	CF14	Sources of project finance		.516				
12	CF1	User comfort during travel			1.056			
13	CF2	Convenience to users			.920			
14	CF6	User safety			.601			
15	CF4	Speed and travel time			.571			
16	CF11	Condition of existing infrastructure, for upgrade projects				.935		
17	CF10	Structural capacity of existing infrastructure, for upgrade projects				.829		
18	CF12	Existing businesses/vendors				.493		
19	DA3	Audit observations and performance reports, for upgrade projects					.924	
20	DA2	Existing design and structural reports, for upgrade projects					.702	
21	CF20	Stakeholders' interests and needs						.832
22	CF21	Competing transportation modes within the locality						.569
23	CF18	Management capacity at operational stage						.482

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 6 iterations.

7.3.2 Feasibility study quality (FQ)

The suitability of the data was assessed by screening for factorability using the well described criteria including the Kaiser-Meyer Olkin (KMO) measure of sampling adequacy, the Bartlett's Sphericity (BTS), and anti-image correlation matrix.

The KMO measure of sampling adequacy was 0.819, exceeding the recommended value of 0.6 and thus "meritorious" and the BTS reached statistical significance at $p = .000$ (χ^2 (45) = 668.293) (Appendix IX-A). The diagonals of the anti-image correlation matrix were all > 0.05 (Appendix IX-B), ranging from 0.654 to 0.906, and thus supporting factorability of the data. These values indicated sampling adequacy for factor analysis. Further, an inspection of the correlation matrix indicated that most variables were greater than 0.30, thus supporting factorability. However, one variable, FQ1 had three coefficients less than 0.3 and a low initial communality estimate of 0.335 (below the recommended 0.4) for factorability of the data (Appendix IX-C). This suggested a lack of patterned relationship with the other factors and therefore may be removed. This item was removed and the analysis repeated. The initial communality estimates of the remaining variables after the rerun ranged from 0.421 to 0.731 and thus indicating factorability of the data (Appendix IX-D).

Further decision regarding how many factors to retain was made based on the Kaiser's criterion, selecting values with eigen value greater than 1 and scree test from the factor extraction. Factor analysis using maximum likelihood factoring revealed that two common factors had eigen values above 1 (4.550 and 1.359), explaining 50.56% and 15.10% of the variance in the sub-model, respectively, and accounting for 65.67% of the total variance (Table 7.9). The scree plot (Appendix IX-E) also supported that two factors could be retained, with a break shown after the second common factor (above 1.0).

Table 7.9: Variance explained by the FQ factors

Factor	Total	% of Variance	Cumulative %
1	**4.550**	**50.560**	**50.560**
2	**1.359**	**15.104**	**65.665**
3	.873	9.700	75.365
4	.733	8.144	83.509
5	.410	4.551	88.060
6	.374	4.160	92.219
7	.290	3.227	95.446
8	.245	2.724	98.170
9	.165	1.830	100.000

Values in bold contribute the most variance in the data set.

The two factors retained were thereafter subjected to rotation using promax oblique method. An examination of the pattern matrix revealed that two of the items did not load well, namely: FQ4, which cross-loaded with more than 0.32 on the second factor, and EX2 which had a low loading, suggesting that they may be removed. The item FQ4 was removed and the rotation rerun. The results (Appendix IX-F) showed that EX2 still had a low loading and it was removed. The emerged structure (Appendix IX-G) then improved, with the items loading strongly (above the recommended 0.4). It is notable that the item *involved environmental specialists* (EX3) had a factor loading of 1.028, and thus indicating that the variable had a high influence or weight in the data set (Rummel, 1970). In addition, although the second common factor had only two variables loading on it, it comprised experts and stakeholders whose views are important in feasibility studies (Brent and Petrick, 2007; Hyari and Kandil, 2009; Schippl, 2016). This structure (Table 7.10) was therefore deemed reliable and used for further analysis.

Table 7.10: Factor loading matrix for FQ measures – Two-factor structure

S/No.	Labels	Measures	Factor	
			1	2
1	FQ9	All possible risks to the project were clearly identified	.890	
2	FQ10	Measures were recommended to manage identified risks	.824	
3	FQ8	All stakeholders were involved in the decision-making process	.767	
4	FQ5	Experts in feasibility study conducted the study	.680	
5	FQ6	Sufficient time was allowed to conduct the feasibility study	.616	
6	EX3	Involved environmental specialists		1.028
7	EX4	Involved professionals who eventually managed (are managing) the projects during the operational stage		.624

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 3 iterations.

7.3.3 Project sustainability measures

With regard to the twenty-eight project sustainable performance measures, the factorability of the data was acceptable based on the KMO measure of sampling adequacy, the Bartlett's test of Sphericity, the initial communality estimates, the correlation matrix and the anti-image correlation matrix.

The Kaiser-Meyer-Olkin (KMO) value for the measure of sampling adequacy was 0.854, exceeding the recommended value of 0.6, and the Bartlett's test of sphericity reached statistical significance at $p = .000$ (χ^2 (378) = 2903.576), suggesting that factor analysis could be performed (Appendix X-A) Inspection of the correlation matrix revealed the presence of many coefficients greater than 0.03, and all the variables correlated with at least one other variable, indicating suitability of data for factor analysis. The anti-image correlation matrix, with diagonals all above 0.5, ranged from 0.735 to 0.926 and thus indicating suitability of the data set for the factor analysis. The initial communality estimates all had values greater than 0.4 (Appendix X-B), and thus further indicating that the data was suitable for factor analysis.

Extraction of the twenty-eight factors revealed six factors with eigen values above 1 (Table 7.11). The eigen values for the six factors contributed 41.58%, 8.62%, 6.60%, 5.98%, 5.11% and 4.22%, accounting for a total of 72.10% of the variance in the data set. Inspection of the scree plot (Appendix X-C) was also suggestive of a six-factor structure for the project sustainability scale. An examination of the extraction communality estimates (Appendix X-B), however, showed that ST5 (0.336) and SQ3 (0.358) were weak and could be removed, since they were observed to have little influence (variance in the data set).

Table 7.11: Variance explained – Project sustainability measures

Factor	Initial Eigenvalues		
	Total	**% of Variance**	**Cumulative %**
1	**11.642**	**41.577**	**41.577**
2	**2.413**	**8.619**	**50.196**
3	**1.848**	**6.599**	**56.795**
4	**1.673**	**5.975**	**62.771**
5	**1.430**	**5.107**	**67.878**
6	**1.181**	**4.218**	**72.096**
7	.983	3.512	75.607
8	.850	3.037	78.644
9	.766	2.737	81.381
10	.651	2.324	83.705
11	.572	2.042	85.748
12	.522	1.864	87.612
13	.466	1.664	89.276
14	.423	1.509	90.785
15	.391	1.395	92.180
16	.304	1.084	93.264
17	.283	1.012	94.276
18	.271	.968	95.244
19	.230	.820	96.064
20	.191	.683	96.747
21	.177	.632	97.379
22	.165	.590	97.969
23	.136	.486	98.456
24	.129	.460	98.916
25	.114	.407	99.323
26	.087	.312	99.634
27	.072	.256	99.891
28	.031	.109	100.000

*Values in bold contribute the most variance in the data set

The rotation of the six retained factors resulted in the explanation of variables as presented in the pattern matrix (Table 7.12). The findings showed that some of the items loaded strongly on the six common factors, with loadings greater than 0.4, while others did not (ST5 and SQ3), supporting the results of the communality extraction values. Further, some of the factors cross-loaded on two or more factors, with a value higher than 0.3 and a decision was made to delete them iteratively. The order in which the items were deleted is presented in Table 7.13.

Table 7.12: Factor loading matrix of project sustainability measures – First run

S/No.	Label	Measures	Factor					
			1	2	3	4	5	6
1	FI1	Capital invested has been recovered	.966					
2	FI3	There are no complaints from investors about revenue	.743			.300	-.358	
3	FI2	There are no complaints about maintenance resources	.627					
4	ST2	Users are satisfied with pricing charges	.615					
5	ST4	The actors are able to work in collaboration with other stakeholders	.560					
6	ST3	There are no operational problems	.539	.326				
7	CI3	There is no traffic overload	.509		.333			
8	ST5	There is clarity of responsibilities among partners	.366					
9	SE3	There are no complaints about inconvenience during travel		.995				
10	SE1	There are no complaints about travel times		.942				
11	SE2	There are no complaints about user discomfort during travel		.889				
12	SE4	There is no competition between different modes of transport		.535				
13	CI4	Infrastructure in its present condition is able to withstand common adverse weather			.824			
14	CI1	The infrastructure is in good condition			.757			
15	SS1	Signage for safety is adequate			.695		-.337	
16	ST1	The needs of the stakeholders are satisfied	.300		.589			
17	SE7	Infrastructure is accessible by all including the disabled and elderly			.560			
18	SE8	Demand for the infrastructure services is as expected			.472		.462	
19	CI2	There are no complaints about the cleanliness of the infrastructure			.417			
20	SS5	Formalised sidewalks are in place for pedestrians			.398			
21	SS3	Security officers are visible				.701		
22	SS4	Security cameras are in place				.677		
23	SS2	Fencing (median is in place for safety				.534		
24	SQ2	Management responds quickly to user complaints about safety incidents					.853	
25	SQ1	Management responds quickly to user complaints about infrastructure services	.334				.618	
26	SQ3	The infrastructure services (rides) are predictable					.372	
27	SE6	New business ventures have developed after the infrastructure was built						.954
28	SE5	Property values have increased after the infrastructure was built				.377		.468

Extraction Method: Maximum Likelihood. Rotation Method: Promax with Kaiser Normalisation.

Table 7.13: Order of deletion of project sustainability measures for repeated rotations

S/No.	Label	Measure	Factor loading informing decision to delete
1	ST5	There is clarity of responsibilities among partners	Low communality 0.336 and low loading 0.366
2	SQ3	The infrastructure services (rides) are predictable	Low communality 0.358 and low loading 0.378
3	SS5	Formalised sidewalks are in place for pedestrians	Low loading 0.381
4	SE5	Property values have increased after the infrastructure was built	Cross loading 0.301 & 0.486
5	SE8	Demand for the infrastructure services is as expected	Cross loading 0.398 & 0.576
6	SQ1	Management responds quickly to user complaints about infrastructure services	Cross loading 0.363 & 0.585
7	CI3	There is no traffic overload	Cross loading 0.355 & 0.404
8	FI2	There are no complaints about maintenance resources	Cross loading 0.364 & 0.530
9	SQ2	Management responds quickly to user complaints about safety incidents	Cross loading 0.330 & 0.483
10	ST3	There are no operational problems	Cross loading 0.389 & 0.525
11	SS2	Fencing (median is in place for safety	Cross loading 0.304 & 0.444
12	SE4	There is no competition between different modes of transport	Cross loading 0.604 & 0.308
13	ST1	The needs of the stakeholders are satisfied	Low loading 0.462
14	ST4	The actors are able to work in collaboration with other stakeholders	Low loading 0.443

The rotation was undertaken after each deletion. The results of these successive deletions, twelve reruns in total, were presented in Appendices X-D to X-O. After the fifteenth run, a four-factor structure with fourteen variables emerged (Table 7.14). This factor structure was not similar to the (six-factor) theoretical framework, but was considered to be reliable, with loadings above 0.5 and no cross loadings.

In summary, the results of the EFA confirm that feasibility study quality was a two-factor scale, transportation feasibility study (TIFS) factors was a six-factor structure and project sustainability was a four-factor structure, as the criterion of eigenvalues ≥ 1, scree plot, and validated final rotations, respectively. Therefore, all items met the criteria for retention with primary loadings on a single factor, discriminant validity was achieved, and they were retained for further analysis using SEM.

Table 7.14: Factor loading matrix of project sustainability measures (final)

S/No.	Label	Measures	Factor 1	Factor 2	Factor 3	Factor 4
1	CI4	Infrastructure in its present condition is able to withstand common adverse weather	.820			
2	CI1	The infrastructure is in good condition	.818			
3	SS1	Signage for safety is adequate	.772			
4	SE6	New business ventures have developed after the infrastructure was built	.688			
5	SE7	Infrastructure is accessible by all including the disabled and elderly	.673			
6	CI2	There are no complaints about the cleanliness of the infrastructure	.529			
7	SE3	There are no complaints about inconvenience during travel		.994		
8	SE1	There are no complaints about travel times		.910		
9	SE2	There are no complaints about user discomfort during travel		.894		
10	FI1	Capital invested has been recovered			.808	
11	FI3	There are no complaints from investors about revenue			.630	
12	ST2	Users are satisfied with pricing charges			.617	
13	SS4	Security cameras are in place				.823
14	SS3	Security officers are visible				.820

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation..
a. Rotation converged in 5 iterations.

7.4 NAMING OF COMMON FACTORS FROM FACTOR ANALYSIS

The common factors that emerged from the EFA further formed the basis of the theory. After the EFA, it was necessary to rename them where necessary, in line with extant literature. Theoretical specifications prior to further analysis using SEM was crucial in order to confirm or refute the theory and hypotheses as postulated. Therefore, the emerging common factor structures from EFA were named and/or renamed, taking into account the common themes among the variables measuring them as defined by the pattern matrices. These are discussed hereunder.

7.4.1 Transportation infrastructure feasibility study

The TIFS measures emerged as a six-factor structure. The factors were named in relation to extant literature as discussed hereunder.

7.4.1.1 Investment appraisal methods

The first common factor contained items initially theorised as methods used in feasibility studies (Etemadnia and Abdelghany, 2011; Al-Masaeid and Al-Omoush, 2014:329). These included *best scenario outcome, site/location characteristics, design and scope requirements, traffic growth analysis, costs and benefits analysis,* and *multi-criteria analysis* and thus the term "appraisal methods*"* was retained. The term "investment appraisal methods" was also used to connote methods used in supporting decision-making in road project investment evaluations and thus it was adopted in the current study (Tánczos and Kong, 2001).

7.4.1.2 Finance availability and source

The second factor comprised items related to financial connotations, including *financial input from private investors, financial self-sustenance of the system, financing alternatives relative to costs (financial), existing financial and tender records* and *sources of project finance.* This factor comprised financial factors considered in feasibility studies as identified by Griskeicius and Griskeviciute-Geciene (2008) and were therefore named "finance availability and source".

7.4.1.3 User needs

Elements that related to users and their travel needs of transportation infrastructure congregated on the third common factor. These included *user comfort during travel, convenience to users, user safety* and *speed and travel time.* These items suggested reference to the experience or perceptions of end users or consumers of transportation infrastructure while in operation. In Hyari and Kandil (2009), similar items (vehicle operating costs and travel time savings) were termed "benefits to users". Users of transportation infrastructure are external factors which could act on the level of investment, value-add or costs, with their input, perception or opposition and should be taken into account during feasibility studies (Griskeicius and Griskeviciute-Geciene, 2008). Users are instrumental in directly influencing decision-making regarding transportation infrastructure and thus their needs and potential benefits should be considered during planning (Cornet, 2016:53).

Based on this notion, the user-related items, which loaded on the third factor, were collectively encoded as *user needs.*

7.4.1.4 Local environment

The fourth common factor consisted of factors connoting status quo with regard to infrastructure condition, structural capacity and businesses or vendors to be considered in the vicinity. Transportation infrastructure planning considers previous developments and current status in a catchment area (including the beneficiaries' and physical infrastructure conditions) in order to compare and develop and compare scenarios while predicting future impact, opportunities and benefits accruable from the project (Hyari and Kandil, 2009; Asian Development Bank (ADB), 2013b) Information on current trends and activities or patterns of behavioural and professional activities around the area, as well as services and facilities that could modify traffic flows (origin and destination) are vital considerations in transportation infrastructure feasibility studies (European Union, n. d.; Halil *et al.*, 2016). In Halil *et al.*'s study, these items were referred to as local economy factors surrounding a proposed project. On this premise, *the condition of existing infrastructure and structural capacity for upgrade projects* as well as *existing businesses/vendors* were denoted as *local environment*.

7.4.1.5 Available data

The fifth common factor had two item-loadings on it. These included statements related to sources of data referred to during feasibility studies. These included *audit observations and performance reports, for upgrade projects* and *existing design and structural reports, for upgrade project.* This factor, although having only two item loadings, was retained because data is an essential component of feasibility studies. The items were related to existing data on which forecasts and projections can be made for the useful life of a project, as opined by Hyari and Kandil (2009:68). Data availability is an essential feature in the development of criteria to assess the level of sustainability of planned infrastructure during feasibility studies (Cornet, 2016:53). The term *available data* was therefore used for the fifth common factor.

7.4.1.6 Strategic support

The emerging structure on the sixth common factor showed variables that influence people's preferences among different modes and fulfil strategic intents and needs of various stakeholders in a bid to achieve failure-free infrastructure (Matti *et al.*, 2017). To avoid failures, operators choose optimal routes and consider long-term performance of the project by involving different levels of executives and expertise in making strategic decisions based on stakeholder and professional input (Dey, 2001). In Schutte and Brits (2012), strategic support factors included policies, strategies and management factors which impact on decision-making regarding investment in transportation infrastructure. Based on these conceptions, the factors which loaded on the sixth common factor, including *competing transportation modes within the locality, stakeholders' interests and needs, management capacity during operations* and *was conducted by professionals with relevant experience on feasibility studies,* was denoted as "strategic support".

7.4.2 Feasibility study quality

The two-factor solution which emerged from the measures of feasibility study quality corresponded with the theorised model. The first common factor mostly had the items related to procedures loading on it. These included *all possible risks to the project were clearly identified, measures were recommended to manage identified risks, all stakeholders were involved in the decision-making process, experts in feasibility study conducted the study* and *sufficient time was allowed to conduct the feasibility study* (Hyari and Kandil, 2009). Although these factors comprised a mixture of procedures and people, the factor was named *procedures* because there were more items related to this. These entailed procedures for the identification of potential risks and uncertainties as well as developing measures to handle identified risks (Cornet, 2016).

The term *people* was retained for the items which loaded on the second common factor. These items included *involved environmental specialists* and *involved professionals who eventually managed (are managing) the projects during the operational stage.* These factors were possibly grouped together because there are different views on what requirements or progress can be expected during the operational phase of transportation infrastructure projects and therefore the feasibility studies should include different experts and stakeholders in developing scenarios (Hyari and Kandil, 2009; Schippl, 2016). Moreover, the scope of the various functional inputs including operations, environmental and technical considerations, which do not work in isolation, but in a continuous dialogue with one another, at different phases of a project, will be covered with the involvement of various professionals such as were grouped together in the second common factor (Brent and Petrick, 2007). Therefore, the second common factor was retained albeit with two items only, as it made theoretical and practical sense to have various people involved in feasibility studies.

7.4.3 Project sustainability measures

The project sustainability measures emerged as a four-factor structure. These were named as follows:

7.4.3.1 Infrastructure condition and impacts

The measures which loaded on the first common factor were related to the condition of the physical infrastructure as well as the impacts, value-add or payback that its existence brings. The items which loaded here included *the infrastructure is in good condition, infrastructure in its present condition is able to withstand common adverse weather*, *signage for safety is adequate*, *infrastructure is accessible by all including the disabled and elderly, new business ventures have developed after the infrastructure was built,* and *there are no complaints about the cleanliness of the infrastructure.* These were related to the real situations and impacts that are evidenced by objective evaluation of condition and information regarding the physical infrastructure and desired impacts from its use (Toth-Szabo and Várhelyi, 2012:2038). Therefore, the first common factor was named *infrastructure condition and impacts.*

7.4.3.2 User acceptability

With regard to the second common factor, items which loaded thereon had to do with complaints associated with the use of the infrastructure system. These included *there are no complaints about inconvenience during travel*, *there are no complaints about travel times* and *there are no complaints about user discomfort during travel.* The level of complaints or opposition to the implementation of a proposed infrastructure project or an existing one shows the level of acceptability and/or usability of the facility (Cornet, 2016:55). Users are more familiar with the context of their immediate physical surroundings and the value-in-use ascribed to transport infrastructure is a significant indicator of transportation infrastructure project sustainability (Cornet, 2016; Okoro, 2018). Sustainability is related to the values and value systems of people, taking into account the social aspect (Toth-Szabo and Várhelyi, 2012:2036). This second common factor was therefore named *user acceptability*.

7.4.3.3 Financial sustainability

The third factor materialised as factors related to the management of the transportation infrastructure projects, especially with regard to finance, during the operational period. The items here included *capital invested has been recovered, users are satisfied with pricing charges,* and *there are no complaints from investors about revenue.* Accountability and effectiveness of all levels of government to cater for present and future growth reflects the quality of the service in terms of efficient management of resources including finance as well as effective collaboration to deliver services (Zhou, 2012:159). The questions of who pays for the infrastructure and their willingness to pay (revenue structure), as well as who manages the cash flow and to what use (services) the financial resources are put (cost or expense structures and investment needs) are forces that drive financial sustainability on transportation projects (Calitz and Fourie, 2007; Toth-Szabo and Várhelyi, 2012; World Bank, 2017a). This is even more important given that the users ultimately pay for the infrastructure and services.

7.4.3.4 Safety and security

The factors which loaded on the fourth factor included *security cameras are in place,* and *security officers are visible*. These variables are objective indicators of safety as they are based on tangible quantitative information regarding the safety and security of transportation projects (Toth-Szabo and Várhelyi, 2012:2040). Since the variables emerged as they were theorised, the denotation was retained.

In summary, the emerged factor structures were similar to the theorised model. For instance, for the feasibility study quality measures, a two-factor structure was theorised. The structure was retained after the EFA, comprising procedures and people. The *people* comprised *involved environmental specialists,* and *involved professionals who eventually managed (are managing) the projects during the operational stage*. These were in line with Hyari and Kandil's (2009) proposition that a feasibility study should essentially entail involvement of qualified professionals as well as stakeholders whose interests should be considered in project development and planning. Some of the items that were theorised as people loaded on the procedures construct. This underlines the importance of having the right people to undertake feasibility study procedures as these cannot really be isolated. Moreover, maintenance capacity assessment is conducted during feasibility studies to identify personnel (individuals, groups or state) and suitable approaches to mobilise resources for the operations and maintenance phase of projects (Unitd Nations, 2015). Feasibility studies should involve independent reviewers and auditors, environmentalists, and managers who will eventually manage the infrastructure assets during the operational stage (Hyari and Kandil; 2009).

With regard to the transportation infrastructure feasibility study (TIF) measures, the initially theorised three-factor structure (data, criteria factors considered and methods used) with forty-two items emerged as a six-factor structure consisting of methods, finance availability and sources, user needs, local environment, data used and strategic support. It is notable that criteria factors as they were theorised emerged restructured into finance availability and source, user needs, local environment and strategic support factors. In other words, these elements were included in the theorised factors but initially congregated into "criteria factors considered". The other theorised factors (methods and data used) were retained. These findings were consistent with Marcelo's (2016) study, which indicated that these factors should be considered in feasibility studies to guide the prioritisation and selection of infrastructure projects by governments who must decide on the allocation of limited fiscal resources. Therefore, strategic inputs and expected outputs (as was the case with the Gautrain) have to be considered. In a bid to accommodate policy objectives, and attend to social and economic needs of the populace, the feasibility study should also take advantage of available data whilst promoting capacity building and data collection, using appropriate and sophisticated appraisal and selection frameworks and methods, to define criteria as well as share information and analysis publicly (Marcelo, 2016:1).

The findings with regard to project performance, which emerged as a four-factor structure including infrastructure condition and impacts, user acceptability, financial management factors, as well as safety and security was not surprising. This finding emphasised the importance of these factors as core elements of sustainable infrastructure development. Unsurprisingly, the criticality of these factors have been emphasised in extant literature. For instance, the importance of user acceptability as a key component of project sustainability was accentuated by the GCR (2016) and in the study by Valentin et al (2012), where the level of acceptability and/or opposition and complaints was reflected in the development of an educational facility and nuclear power plant, respectively.

Infrastructure condition (Ramani *et al.*, 2009; Fay and Toman, 2010; Karlaftis and Kepaptsoglou, 2012), as well as safety and security have also been the focus of many a discourse as regards sustainable transportation infrastructure development (Quium, 2014; Upadhyaya *et al.*, 2014; Cottrill and Derrible, 2015; Barnes-Dabban *et al.* 2017).

The finding that institutional factors did not emerge strongly was, however, surprising. One institutional variable, *the actors are able to work in collaboration with other stakeholders, g*rouped under the financial management factors. This finding is inconsistent with views expressed in extant literature that institutional sustainability has to do with success in dealing with coordination issues in operation and management of infrastructure networks and/or systems as well as the capacity and readiness of the transportation system administration and stakeholders to collaborate in the delivery of infrastructure to ensure sustainability (Toth-Szabo and Várhelyi, 2012:2041; Quium, 2014:49). The grouping of actors' ability to collaborate with financial management factors could be because financing is a major aspect of transport management and operations whereby the effort of all stakeholders are required in the delivery of transportation infrastructure, especially on PPP projects (Cornet *et al.*, 2018).

7.5 STRUCTURAL EQUATION MODELING

The structural modeling process was centred on two main steps: validating the measurement model and fitting the structural model. However, prior to the analysis, preliminary analysis was conducted to assess the distribution of the data with regard to missing data, univariate and multivariate normality, and outliers.

7.5.1 Preliminary analyses

7.5.1.1 Missing data

Missing data were identified and treated using mean imputation. This entailed computing the average response on a particular variable with missing data and imputing the value for the missing data, respectively. Subsequently, it was possible to assess the multivariate normality of the data, and identify outliers that were contributing to the non-normal distribution of data.

7.5.1.2 Univariate and multivariate normality and outliers

Further examination was conducted to detect multivariate normality and outliers using univariate skewness and multivariate kurtosis (*Mardia's* coefficient), as well as Mahalanobis d-squared distance tests. Some of the variables exhibited non-normality, with absolute (univariate) values for skewness exceeding the recommended 1.0 (values in bold, in Appendix XI). With regard to the kurtosis values, they did not exceed the recommended value of 1.96, and *Mardia's* coefficient were observed to be slightly large, especially for the TIFS and PS sub-models, 204.848 and 114.870 respectively. For the FQ model, the *Mardia's* coefficient was 34.868. The large coefficients for the TIFS and PS sub-models indicated that there was significant kurtosis and therefore significant non-normality. Further, the Mahalanobis d-squared distance test results (Appendix XII) for particular cases (responses) showed the observations which might be contributing to the non-normality (outliers) in the data set. The outlying cases were observations farthest from the centroid, as shown in descending order.

A decision was therefore made to delete the cases with the highest d-squared values in order to reduce the *Mardia's* coefficient and thus the effect that the outliers had on the analysis results (Byrne, 2001:277). The cases, which showed high d-squared values across two or all of the sub-models or constructs were deleted. These were observed to contribute to the multivariate non-normality across the entire data set. It is notable that a consideration was made to delete all the observations with $p < 0.005$. However, this was not done because as opined by Gao *et al.* (2008), it is not always advisable to delete all the cases having $p < 0.005$ since the presence of those outliers may be reflective of the nature of the cases. Moreover, it was observed that deleting all the cases with $p < 0.005$ would have drastically reduced the sample size (number of observable cases) and in turn the degrees of freedom.

Therefore, seven cases including observation numbers 42, 53, 57, 86, 87, 95, and 125, were deleted. It was observed that some may be outliers because they could belong to another sub-model and not others or probably some respondents did not follow instructions and therefore responses provided may not be relevant to the study objectives (Byrne, 2001; Schrieber, 2006; Crowson, 2016). The normality tests were thereafter rerun with a total of 125 observations in order to improve the *Mardia's* coefficient and subsequently, the model fit.

The skewness and kurtosis values after deleting the outliers were presented in Appendix XIII. The absolute skewness values for the feasibility study quality measures improved, with skewness values for most of the items below 1.0, indicating slight non-normality. With regard to the multivariate kurtosis, improvements were noticeable with three sub-models having *Mardia's* coefficients of 139.097, 21.935 and 110.812, for TIFS, FQ and PS, respectively. The sub-models were therefore deemed suitable for further analysis.

7.5.1.3 Definability of the model

The definability of the sub-models was determined by assessing the degrees of freedom for the sub-models. The degrees of freedom reflect the number of parameters that are free to vary during estimation or the number of independent values that a statistical analysis can estimate (Frost, 2018). All the sub-models exhibited definability, having positive degrees of freedom, with regard to the first respective runs as well as subsequent ones. Positive degrees of freedom meant that the sub-models were over-identified and could be rejected, therefore rendering them of scientific value (Musonda, 2012:173).

7.5.2 Measurement model fit analysis

The aim of the analysis at this stage was to establish reliability of the observed variables or indicators (Schreiber *et al.*, 2006:327). This was basically undertaken by running the analysis using specified outputs and examining the squared multiple correlations and the modification indices in the following procedure:

- Examining the fit indices obtained for the measurement model;
- Examining the residual matrix for possible areas of misfit and deleting items with high values;
- Deleting items with high correlations (above 1.0) with many other items in the model as evinced from the standardised residuals covariance matrix;
- Deleting items with lowest factor loadings or variance explained in the model (squared multiple correlations below 0.5 were problematic items), one factor at a time;
- Running the new measurement model each time an item was deleted, bearing in mind that item deletion may not exceed 20% of the total number of items and latent constructs should have at least two or three items;
- Examining fit indices for the new measurement model;

- If fit indices were not achieved, checking the modification indices (MI) for items which may be redundant in the model and may be deleted or constrained as free parameters;
- Constraining the redundant or highly covaried items and adding a path, where necessary;
- Examining the fit indices of possible measurement models and selecting best fitting model; and
- Reporting the validity of the remaining constructs and selected measurement model.

Therefore, the results were presented on residual covariance matrix and distribution of standardised residuals, goodness of fit statistics, squared multiple correlations (variance explained) and reliability and validity evaluations.

The relationships between the latent constructs and variables were sought and measurement model fit determined for further structural modeling analysis. The data were from 125 cases with complete responses (real and imputed data) on TIFS, FQ and PS measures. The pattern matrix after EFA was imputed into the AMOS software using the pattern matrix builder. The latent constructs were tested, respectively.

The measurement models showed the relationships between the latent constructs and their variables. For each of the sub-models, the ovals represent latent constructs measuring feasibility study quality (risks and precautions; and alternative solutions). The rectangles are the observed variables or indicators of each latent construct. The ovals represent the latent constructs. The error terms for each observed variable are represented as circles. These are residual or error variances, which uniquely cause response variations in the observed variables. The measurement models were tested using CFA, and specifically, the model generating approach, to determine the model with the best fit (Byrne, 2001). Therefore, the fit indices for the emerging model after each run were presented. A two-index presentation strategy (using absolute and comparative fit indices) as advocated by Hu and Bentler (1999) was adopted.

7.5.2.1 Transportation infrastructure feasibility study (TIFS) measurement model

The input TIFS model into AMOS from the EFA was presented in Figure 7.1. The measures were summarised in Table 7.15. The relationships between and among latent constructs and their variables were shown.

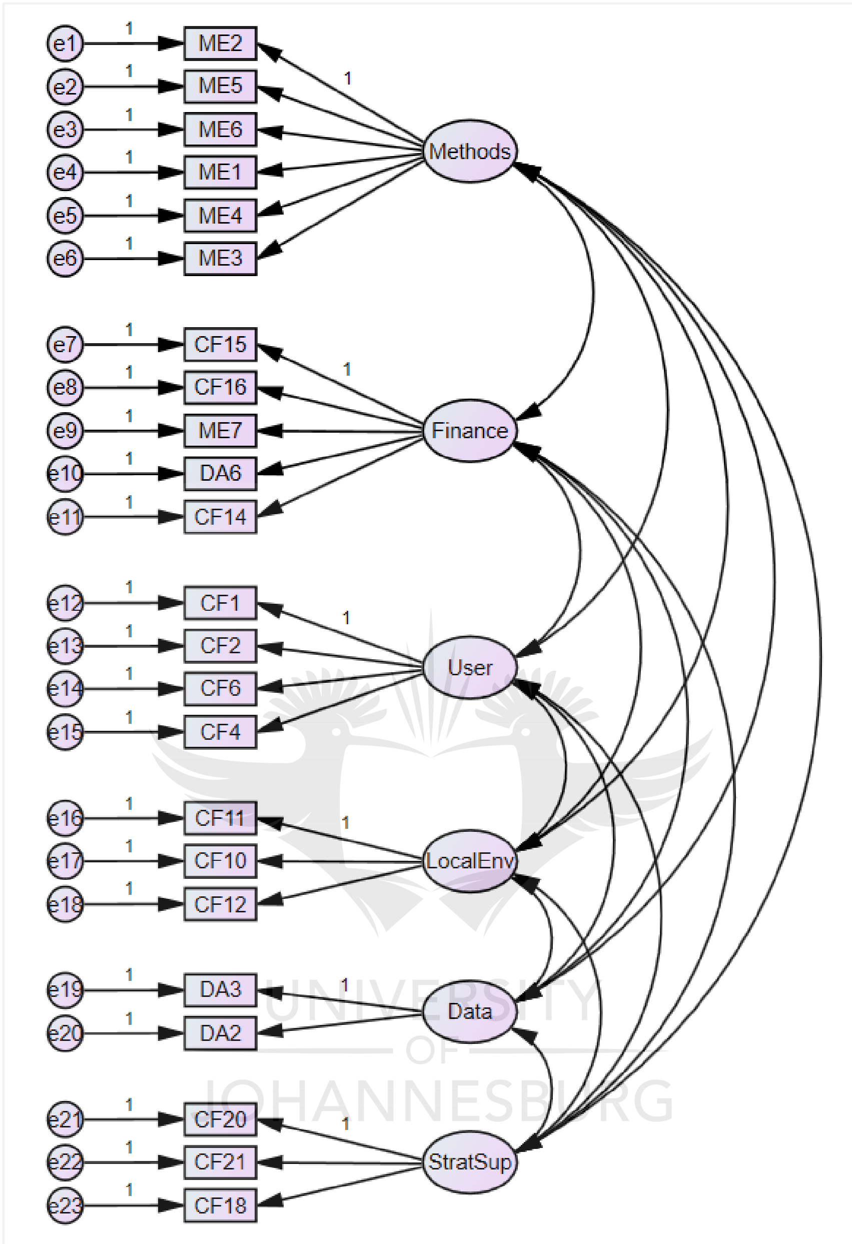


Figure 7.1: Theorised six-factor TIFS model

Table 7.15: Transportation infrastructure feasibility study (TIFS) measures

S/No.	Construct	Measures	Label
1	Methods	Best scenario outcome	ME2
		Site/locational characteristics	ME5
		Design and scope requirements	ME6
		Traffic growth analysis	ME1
		Costs and benefits analysis	ME4
		Multi-criteria analysis	ME3
2	Finance availability and sources	Financial input from private investors	CF15
		Financial self-sustenance of the system	CF16
		Financing alternatives relative to costs (financial)	ME7
		Existing financial and tender records	DA6
		Sources of project finance	CF14
3	User needs	User comfort during travel	CF1
		Convenience to users	CF2
		User safety	CF6
		Speed and travel time	CF4
4	Local environment	Condition of existing infrastructure, for upgrade projects	CF11
		Structural capacity of existing infrastructure, for upgrade projects	CF10
		Existing businesses/vendors	CF12
5	Available data	Audit observations and performance reports, for upgrade projects	DA3
		Existing design and structural reports, for upgrade projects	DA2
6	Strategic support	Stakeholders' interests and needs	CF20
		Competing transportation modes within the locality	CF21
		Management capacity at operational stage	CF18

Initial TIFS model fit analysis

Initial evaluation of the input model showed that there were no high correlations (exceeding 0.80) between the latent constructs, and thus indicating discriminant validity from the EFA output. Inter-construct values ranged from 0.11 to 0.63 (Appendix XIV-A).

Evaluation of the input model fit indices (Table 7.16) revealed that the model did not match the data. The chi-square was significant ($\chi 2$ = 513.215, *df* = 215, p = 0.000), indicating that the postulated model was significantly different from the sample data. However, since the chi-square was not really reliable due to sensitivity to sample size, other criteria were checked. Results revealed that CMIN/*df* = 2.387 (cut-off value = ≤ 2 or 3), CFI = 0.853 (cut-off value = ≥ 0.90), SRMR = 0.094 (cut-off value = > 0.05 to 0.08; 1.0 is acceptable), and RMSEA = 0.106 (cut-off value = 0.09). These values indicated that the postulated TIFS model did not match the data and therefore a decision was made to apply modifications to the model.

Table 7.16: Fit indices for TIFS input model

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		513.215	
Degrees of freedom *df*	> 0 ; positive	215	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.387	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.853	Not acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.094	Not acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.106	Not acceptable

Diagnostic fit analysis

Initial diagnostic analysis was undertaken by examining the output from the standardised residuals covariance matrix (Appendix XIV-B). The results showed that a lot of variables were well above 2.0 in covariance with other items in the model. Values should not be above 2.58 as recommended by Byrne (2006), for the model to be described as matching the sample data. This also indicated that some statements may have been misunderstood, or had biased responses and thus may be removed since they were causing multi-collinearity in the model. For a model to be said to be well-fitting, the standardised residuals should be symmetrical and centered around zero (Musonda, 2012:175). Therefore, items which had high correlations were identified for deletion one after another.

Model modification

The inspection of the standardised covariance matrix revealed that there were high covariances between:

- DA6 (*existing financial and tender records*) and CF18 *(management capacity at operational stage)* with 3.585 and DA2 (*existing design and structural reports, for upgrade projects*) with 2.722;
- ME1 (*traffic growth analysis*) and CF4 (*speed and travel time*) with 2.750;
- ME3 (*multi-criteria analysis*) and CF4 (*speed and travel time*) with 2.709; and
- CF6 (*user safety*) and CF12 (*existing businesses/vendors*) with 2.603.

The high covariances indicated that the items may have been ill-defined, misunderstood or biased and thus should be removed. The high covariances exhibited between methods (ME1 and ME3) and CF4 suggested that irrespective of the appraisal methods used in feasibility studies, the benefits accruing from the usage of the system are important considerations. In order to define models during transportation infrastructure feasibility studies, to simulate current scenarios and assess future ones, information regarding the needs of travellers including travel time savings and faster mobility needs are important (Nuzzolo and Comi, 2014). It was notable that the item, CF4 (*speed and travel time*) also had a high covariance with six other items in the model. The covariance found between user safety and existing businesses in the area had to do with the users and although important, CF6 had to be removed because it was causing multicollinearity in the model. The items DA6, ME1, ME3 and CF6 were therefore deleted one after the other and the test rerun.

The results of the model fit after each deletion and repeated test were presented in Table 7.17. As can be espoused from the table, the model fit improved with the fifth run, with CMIN/df = 2.219 (cut-off value = ≤ 2 or 3), CFI = 0.894 (cut-off value = ≥ 0.90), SRMR = 0.0915 (cut-off value = > 0.05 to 0.08), and RMSEA = 0.099 (cut-off value = 0.09). However, the high SRMR suggested that there were still residual variances contributing to the poor model fit.

Table 7.17: Fit indices results for repeated runs of the TIFS model

Fit indices	Cut off value	2nd run (DA6 removed)	3rd run (ME1 removed)	4th run (ME3 removed)	5th run (CF6 removed)
χ^2		460.026	422.784	359.500	303.948
df	> 0 ; positive	194	174	155	137
CMIN/df	≤ 2 or 3	2.371	2.430	2.319	2.219
CFI	≥ 0.90	0.865	0.866	0.880	0.894
SRMR	> 0.05 to 0.08	0.0938	0.0937	0.0933	0.925
RMSEA	< 0.09 – good fit < 1.0 – reasonable fit	0.105	0.107	0.103	0.099

An inspection of the modification indices after the fifth run (Appendix XIV-C) showed that there were no high covariance values. Modification indices values above 15 should be treated (Awang, 2012). Consideration was also made to delete items with squared multiple correlations less than 0.4 and factor loading of less than 0.6 (Awang, 2012).

An inspection of the squared multiple correlation matrix after the fifth run (Appendix XIV-D) revealed items contributing the lowest to the variation in the model. These were CF14 (40%), CF21 (41%) and CF4 (43%). However, given that almost 20% of the total number of items were already deleted and the lowest value was equal to 0.4 and could be retained, the squared residuals

(Appendix XIV-E) were viewed once again for problematic items. It was found that CF4 still had a high covariance (2.909) with CF21, exceeding the recommended threshold of 2.58 (Byrne, 2006). The decision was then made to delete CF4. The model fit indices were acceptable with sixth run. It was notable that only 5 items were deleted from the TIFS model, which was approximately 20% of the number of items from the EFA and this was permissible.

A further examination of the squared multiple correlations revealed that CF2 had a correlation value above 1.0 (Appendix XIV-F). Squared multiple correlations values greater than 1.0 are unreasonable (Byrne, 2006; Musonda, 2012). This anomaly was treated by constraining and suppressing the regression weight for the variable. This resulted in shared variance with CF1 in the same latent construct.

The resultant model was deemed to acceptable based on Hu and Bentler's two-index presentation strategy. The results of the model fit indices (Table 7.18) after the seventh run: CMIN/*df* = 1.828 (cut-off value = ≤ 2 or 3), CFI = 0.931 (cut-off value = ≥ 0.90), SRMR = 0.0768 (cut-off value = > 0.05 to 0.08), and RMSEA = 0.082 (cut-off value = 0.09) were all acceptable. The TIFS model, Figure 7.2 was therefore selected for further structural modeling,

Table 7.18: Fit indices after the TIFS model – Sixth and seventh runs

Fit indices	**Cut off value**	**6th run (CF4 removed)**	**7th run (regression weight suppressed on CF2 path)**
χ^2		220.734	221.129
df	> 0 ; positive	120	121
CMIN/*df*	≤ 2 or 3	1.839	1.828
CFI	≥ 0.90	0.931	0.931
SRMR	> 0.05 to 0.08	0.0773	0.0768
RMSEA	< 0.09 – good fit < 1.0 – reasonable fit	0.082	0.082

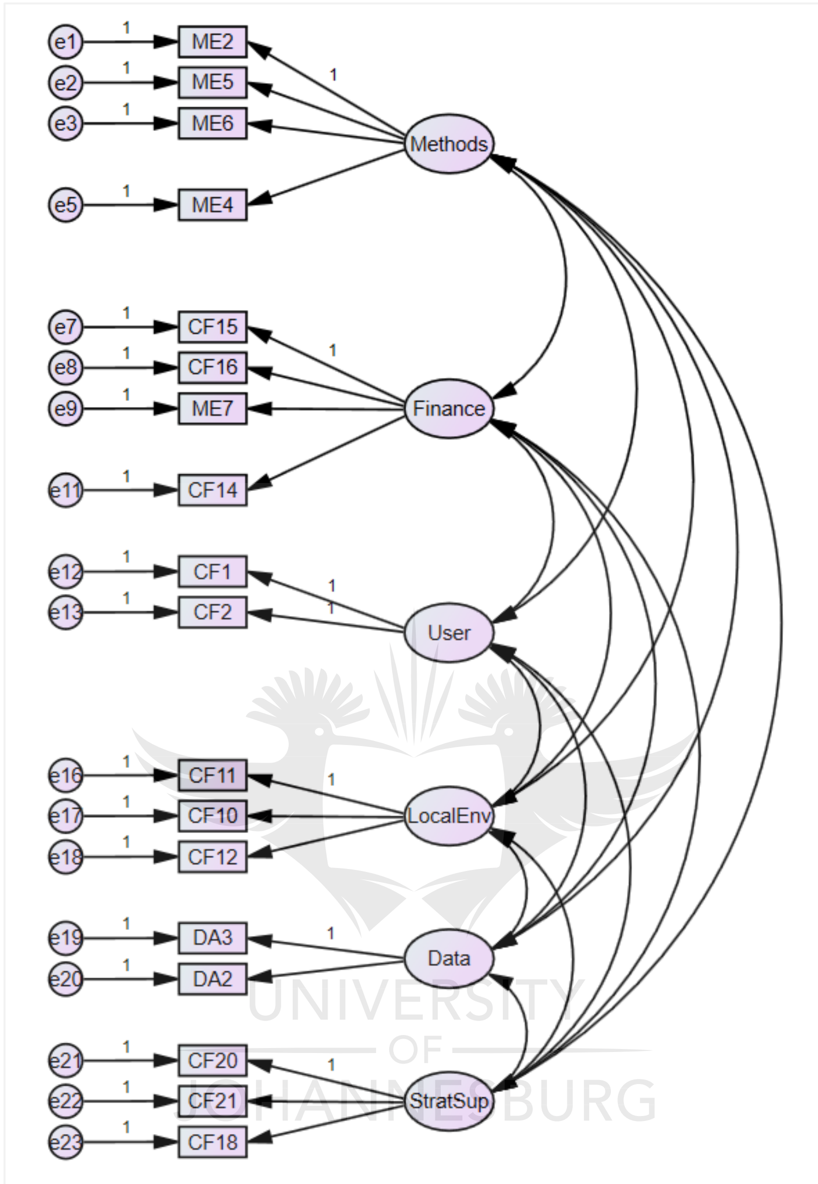


Figure 7.2: Selected TIFS measurement model

Statistical significance of parameter estimates

Further examination of the factor loadings (regression weights), standard errors and critical ratio estimates were undertaken in order to decipher if the model parameters were statistically significant (Musonda, 2012:179). This was necessary in order to make conclusions regarding the appropriateness of the model.

The TIFS final measurement model parameters exhibited statistical significance with the squared multiple correlations values all less than 1.0, ranging from 0.401 to 0.971, and therefore reasonable. The parameter estimates had high correlation values (above 0.4). The correlation values suggested a high degree of linear association between the indicator variables and their latent constructs.

In addition, the critical ratio test statistic, akin to *Z* scores, was used to test the significance of the parameters. The critical ratio or *Z*-statistic is the parameter estimate divided by its standard error. The critical ratio values needed to be greater than 1.96 at the 0.05 significance level for it to be statistically different from zero and considered significant. Table 7.19 containing the parameter estimates, showed that the critical ratio values were all above 1.96 and therefore statistically significant.

Table 7.19: Parameter estimates of the selected TIFS measurement model

Latent construct	**Variable**	**Squared multiple correlations R^2**	**Factor loading (unstandardised λ)**	**Factor loading (standardised λ)**	**Critical ratio**	**Significant at 0.05 level?**
Methods	ME2	.747	1.000	.864	…	Yes
	ME5	.866	1.101	.931	14.989	Yes
	ME6	.842	.993	.918	14.588	Yes
	ME4	.649	.985	.806	11.434	Yes
Finance availability and source	CF15	.584	1.000	.764	…	Yes
	CF16	.845	1.086	.919	9.629	Yes
	ME7	0.427	.694	.654	7.248	Yes
	CF14	0.401	.651	.634	7.003	Yes
User needs	CF1	.770	1.000	.877	…	Yes
	CF2	.971	1.000	.986	…	Yes
Local environment	CF11	.923	1.000	.961	…	Yes
	CF10	.698	.875	.836	12.626	Yes
	CF12	.453	.856	.673	8.915	Yes
Available data	DA3	.757	1.000	.870	…	Yes
	DA2	.752	.978	.867	6.742	Yes
Strategic support	CF20	.727	1.000	.853	…	Yes
	CF21	.407	1.090	.638	6.967	Yes
	CF18	.446	.869	.668	7.328	Yes

… Values not determined due to unstandardised regression weight of 1.0

Reliability and validity of the feasibility study elements measurement model

The reliability of the measurement model for feasibility study elements was evaluated using the formulae for Composite Reliability (CR) and Average Variance Extracted (AVE) tests (Equations 7.1 and 7.2).

$$CR = \frac{(\Sigma\lambda_j)^2}{[(\Sigma\lambda_j)^2 + \Sigma(1-\lambda_j^2)]}$$ **Equation 7.1**

$$AVE = \frac{\Sigma\lambda_i^2}{n}$$ **Equation 7.2**

where λ is the factor loading, and *n* is the number of items in the model.

The CR values should be above 0.6 and the AVE scores should be above 0.5 (Awang, 2012). The results of the CR and AVE tests presented in Table 7.20, indicated that the required levels were achieved for the latent constructs in the TIFS measurement model and thus the model was deemed reliable.

Additionally, convergent, construct and discriminant validity were achieved. Convergent validity was achieved by the AVE values in all being above 0.5 (Table 7.20). Construct validity was achieved by the model being of good fit, with all the fit indices within the recommended cut-off ranges, CMIN/df = 1.828, CFI = 0.931, SRMR = 0.0768 and RMSEA= 0.082, indicating acceptable fit. Discriminant validity was achieved by the modification indices values below 15 Appendices XIV-G) and inter-construct correlations less than 0.85.

Further, discriminant validity was achieved based on the findings that the correlation between the constructs were lower than 0.85 for both models (Table 7.21). The table shows the diagonals in bold, which are the square root of the AVE for the constructs, and the other values in rows and column are the correlation between the constructs related. The square root of the AVE values should be greater than the inter-construct correlations for discriminant validity to be achieved (Awang, 2012; Ahmad, 2016). As can be seen from the table, the diagonal values, were greater than the inter-construct correlations and thus discriminant validity was achieved.

Table 7.20: Reliability results for selected TIFS measurement model

Latent construct	Item	Factor loading λ	Composite reliability (> 0.6)	Average variance extracted (> 0.5)	Comment
Methods (n = 4)	ME2	.864	0.963	0.777	Required level was achieved
	ME5	.931			
	ME6	.918			
	ME4	.806			
Finance availability and source (n = 4)	CF15	.764	0.896	0.565	Required level was achieved
	CF16	.919			
	ME7	.654			
	CF14	.634			
User needs (n = 2)	CF1	.877	0.962	0.871	Required level was achieved
	CF2	.986			
Local environment (n = 3)	CF11	.961	0.920	0.692	Required level was achieved
	CF10	.836			
	CF12	.673			
Available data (n = 2)	DA3	.870	0.920	0.755	Required level was achieved
	DA2	.867			
Strategic support (n = 3)	CF20	.853	0.847	0.527	Required level was achieved
	CF21	.638			
	CF18	.668			

Table 7.21: Discriminant validity testing of TIFS model

Construct	Methods	Finance availability and source	User needs	Local environment	Available data	Strategic support
Methods	**0.88**					
Finance availability and source	.38	**0.75**				
User needs	.34	.29	**0.93**			
Local environment	.59	.21	.46	**0.83**		
Available data	30	.07	.25	.49	**0.87**	
Strategic support	.62	.55	.53	.56	.34	**0.73**

7.5.2.2 Feasibility study quality (FQ) measurement model

The input model for the FQ model from EFA was presented in Figure 7.3. The diagram shows the relationships between and among latent constructs and their variables were shown. The measures were as summarised in Table 7.22.

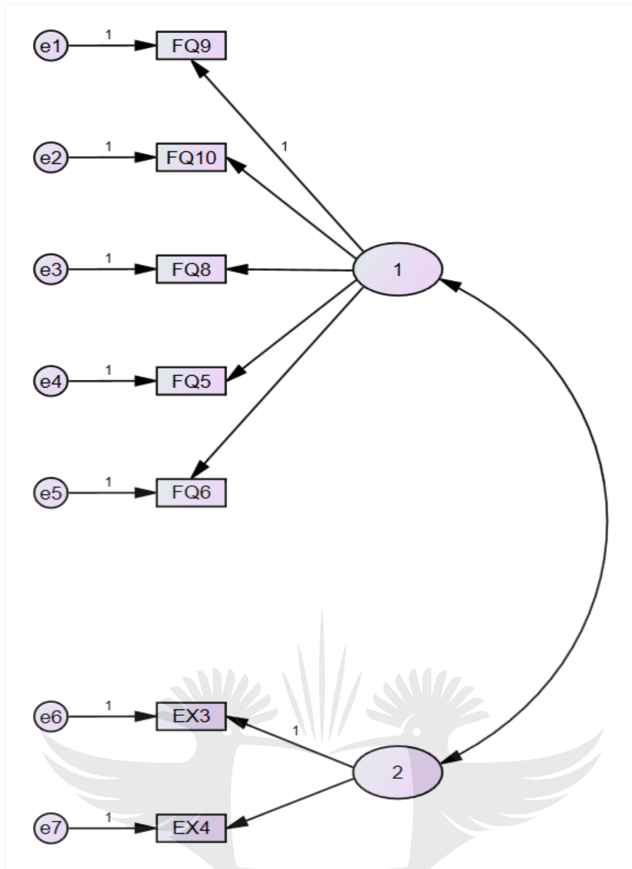


Figure 7.3: Theorised FQ model

Table 7.22: Feasibility study quality measures

S/No.	Labels	Measures	Labels
1	Procedures	All possible risks to the project were clearly identified	FQ9
		Measures were recommended to manage identified risks	FQ10
		All stakeholders were involved in the decision-making process	FQ8
		Experts in feasibility study conducted the study	FQ5
		Sufficient time was allowed to conduct the feasibility study	FQ6
2	People	Involved environmental specialists	EX3
		Involved professionals who eventually managed (are managing) the projects during the operational stage	EX4

Initial FQ model fit analysis

Initial evaluation of the input model showed a moderate correlation (0.50) between the latent constructs and thus indicating that there was sufficient discriminant validity from the EFA outcome.

An evaluation of the input model fit indices (Table 7.23) revealed that the model matched the sample data, based on the two-index strategy advocated by Hu and Bentler (1999). The chi-square was significant (p=0.000) with 13 degrees of freedom, indicating that the postulated model was not significantly different from the sample data.

The results from other goodness of fit indices revealed that for the input model, CMIN/*df* = 3.871 (cut-off value = ≤ 2 or 3), CFI = 0.919 (cut-off value = ≥ 0.90), SRMR = 0.0538 (cut-off value = > 0.05 to 0.08), and RMSEA = 0.152 (cut-off value = 0.09). The values were all within the acceptable ranges, except for the RMSEA. However, based on the SRMR, which informs on the difference between the hypothesised model and sample data, the model was considered a good fit. However, the MI output was examined for areas that may be problematic in the structural model.

Table 7.23: Fit indices for FQ input model

Fit indices	**Cut off value**	**Estimate**	**Comment**
Chi-square χ^2		50.324	
Degrees of freedom *df*	> 0 ; positive	13	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	3.871	Acceptable
Comparative fit index (CFI)	Close to 0.95; ≥ 0.90	0.919	Acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08 (lower is better)	0.0538	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.152	Not acceptable

Diagnostic fit analysis

Initial diagnostic analysis was undertaken by examining the output from the standardised residuals covariance matrix (Table 7.24). The results showed that FQ5 had a high correlation with FQ6. However, the value did not exceed the concerning values of 2.58. This indicated that the model matched the sample data (Byrne, 2006).

Table 7.24: Standardised residual covariances – Input model

	EX4	**EX3**	**FQ6**	**FQ5**	**FQ8**	**FQ10**	**FQ9**
EX4	.000						
EX3	.000	.000					
FQ6	.026	.883	.000				
FQ5	-.324	.600	1.254	.000			
FQ8	-.246	-1.044	-.179	-.307	.000		
FQ10	.613	.357	-.137	-.306	-.368	.000	
FQ9	-.548	-1.096	-.660	-.463	1.022	.379	.000

Model modification

Although the model appeared to match the sample, an inspection of the modification indices informed on a high covariance of 17.468 between e4 and e5, associated with FQ5 (*experts in feasibility study conducted the study*) and FQ6 (*sufficient time was allowed to conduct the feasibility study*), as equally indicated by the residual covariance matrix. The high covariance of 17.468 (above the recommended 15) indicated multi-collinearity problems in the model. The finding that *experts in feasibility studies* was related to the time allowed for feasibility studies was highlighted (Barfod and Leleur, 2014). Expert consultancy is useful in feasibility studies and this takes a considerable amount of time and resources (Brafod and Leleur, 2014). A detailed feasibility study entails involvement of experts such as engineering consultants and this in turn involves considerable commitment of resources including sufficient time for the study, in order to amass relevant information for the study (Hyari and Kandil, 2009). Moreover, feasibility studies should be reviewed and analysed by experts and peer-reviewers knowledgeable on the subject and this process takes time. The covaried items were therefore constrained or set as free parameters and the test was rerun.

The results of the model fit indices after the repeated run, as presented in Table 7.25, revealed that the RMSEA improved slightly but was not quite acceptable. An inspection of the modification indices revealed that there were no worrying concerns (values above 15). However, FQ8 (*all stakeholders were involved in the decision-making process*) had the lowest correlation value, contributing 47% of the variation in the model and it was removed to improve the RMSEA index.

Although it was suggested that only variance values below 0.4 and factor loadings of below 0.6 should be removed (Awang, 2012), it was notable that the deletion of FQ would improve model fit as it contributed more error variance than explained variance to the model. The low correlation value for FQ8 also suggested that it may not belong to the group and may be deleted. Moreover, given the small number of variables in the FQ model, any small error variance (more than 50%) would affect the fit. The item FQ8 was then removed and the test rerun. The model fit indices improved significantly afterwards, as can be seen in Table 7.25, with CMIN/*df* below the recommended value of 2.0, CFI (above 0.90), SRMR below the recommended 0.05, and the

RMSEA below 0.09 as recommended. These results indicated that the model was an excellent fit to the sample data. The final FQ model was presented in Figure 7.4.

Table 7.25: Model fit indices for FQ model

Fit indices	Cut off value	Estimate (2nd run) / Comment		Estimate (3rd run) / comment	
Chi-square χ^2		29.656		12.897	
Degrees of freedom *df*	> 0 ; positive	12	Acceptable	7	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.471	Acceptable	1.842	Acceptable
Comparative fit index (CFI)	Close to 0.95; ≥ 0.90	0.962	Acceptable	0.985	Acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08 (lower is better)	0.0480	Acceptable	0.0409	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.109	Not acceptable	0.082	Acceptable

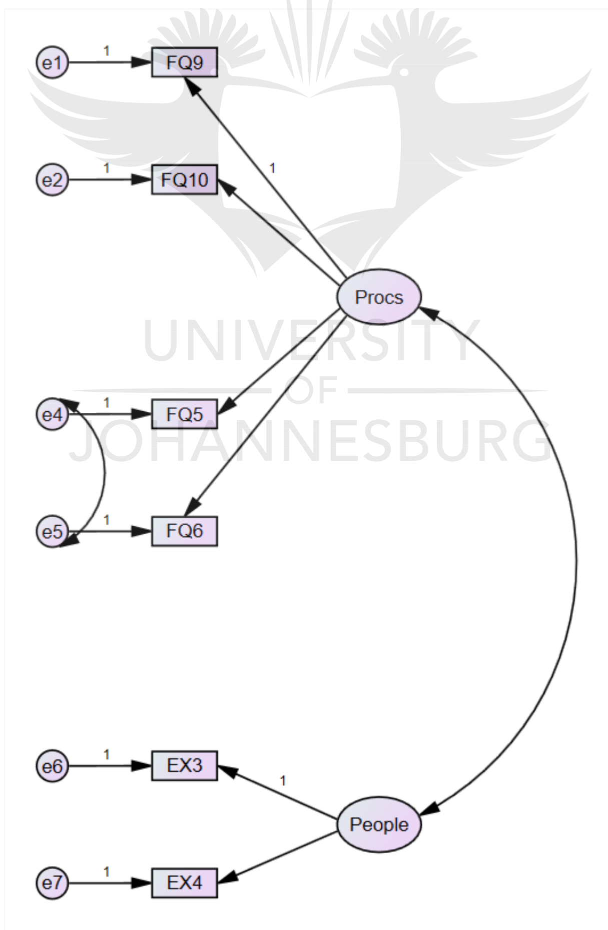


Figure 7.4: Selected FQ measurement model

Statistical significance of parameter estimates

Further examination of the factor loadings (regression weights), standard errors and critical ratio estimates were undertaken in order to assess whether the parameters of the model were statistically significant (Musonda, 2012:179). These were necessary in order to make conclusions regarding the appropriateness of the model.

The FQ final measurement model parameters exhibited statistical significance with the squared multiple correlation values all less than 1.0, indicating that the parameters were reasonable. Parameter estimates should not be greater than +1 or less than 0. The parameter estimates had high correlation values (above 0.4), ranging from 0.46 to 0.89. The correlation values suggested a high degree of linear association between the indicator variables and their latent constructs and therefore significant.

In addition, the critical ratio test statistic, similar to *Z* scores, was used to test the significance of the parameters. The critical ratio or *Z*-statistic is the parameter estimate divided by its standard error. The critical ratio values were greater than 1.96 at the 0.05 significance level and thus significant, as shown in Table 7.26.

Table 7.26: Parameter estimates of the selected FQ measurement model

Latent construct	Variable	Squared multiple correlations R^2	Factor loading (unstandardised λ)	Factor loading (standardised λ)	Critical ratio	Significant at 0.05 level?
Processes	FQ9	0.658	1.000	.811	…	Yes
	FQ10	0.886	.990	.942	10.948	Yes
	FQ5	0.462	.623	.680	8.117	Yes
	FQ6	0.522	.804	.722	8.778	
People	EX3	0.727	1.000	.853	…	Yes
	EX4	0.588	1.009	.767	5.281	Yes

… Values not determined due to unstandardised regression weight of 1.0

Reliability and validity of the feasibility study quality measurement model

The reliability of the measurement model for feasibility study quality was evaluated using the formulae for Composite Reliability (CR) and Average Variance Extracted (AVE) tests (Equations 7.3 and 7.4).

$$CR = \frac{(\Sigma\lambda_j)^2}{[(\Sigma\lambda_j)^2 + \Sigma(1 - \lambda_j^2)]}$$ **Equation 7.3**

$$AVE = \frac{\sum \lambda_i^2}{n}$$ **Equation 7.4**

where λ is the factor loading, and *n* is the number of items in the model.

The CR values should be above 0.6 and the AVE scores should be above 0.5 for reliability to be achieved (Awang, 2012). The results of the CR and AVE tests presented in Table 7.27, indicated that the required levels were achieved for the latent constructs in the FQ measurement model and thus the model was deemed reliable.

Additionally, convergent, construct and discriminant validity were achieved. Convergent validity was achieved by the AVE values all being above 0.5 as presented in Table 7.27. Construct validity was achieved by the model being of good fit, as the fit indices indicated: CMIN/df = 1.842, CFI = 0.985, SRMR = 0.0409 and RMSEA= 0.082. Discriminant validity was achieved by modification index below the recommended threshold of 15 and the inter-construct correlation of 0.51 (below 0.85).

Table 7.27: Reliability results for FQ measurement model

Latent construct	Item	Factor loading λ	Composite reliability (> 0.6)	Average variance extracted (> 0.5)	Comment
Processes (n = 4)	FQ9	.811	0.922	0.632	Required level was achieved
	FQ10	.942			
	FQ5	.680			
	FQ6	.722			
People (n = 2)	EX3	.853	0.874	0.658	Required level was achieved
	EX4	.767			

Further, discriminant validity was achieved with the only modification index between e1 associated with FQ9 (*all possible risks to the project were clearly identified*) and the *people* latent construct below 15 (4.528), indicating that there were no high correlations between the constructs and variables. In addition, discriminant validity was achieved based on the finding that the inter-construct correlation (0.51) between the two latent constructs was lower than 0.85 (Ahmad, 2016:6). Further, the inter-construct correlation (0.51) was lower than the square root values of the AVE scores for *processes* (0.79) and *people* (0.81), and thus indicating discriminant validity. The square root of the AVE values should be greater than the inter-construct correlations for discriminant validity to be achieved (Awang, 2012). Therefore, the selected FQ measurement model was deemed reliable and valid for structural modeling.

7.5.2.3 Project sustainability (PS) measurement model

The project sustainability (PS) input diagram from the EFA output was shown in Figure 7.5. The measures used for the input diagram were presented in Table 7.28. The inter-construct correlations ranged from 0.46 to 0.78, and thus indicating discriminant validity of the four-factor structure from the EFA. The inter-construct correlations should not be more than 0.85 to achieve discriminant validity (Ahmad, 2016:6).

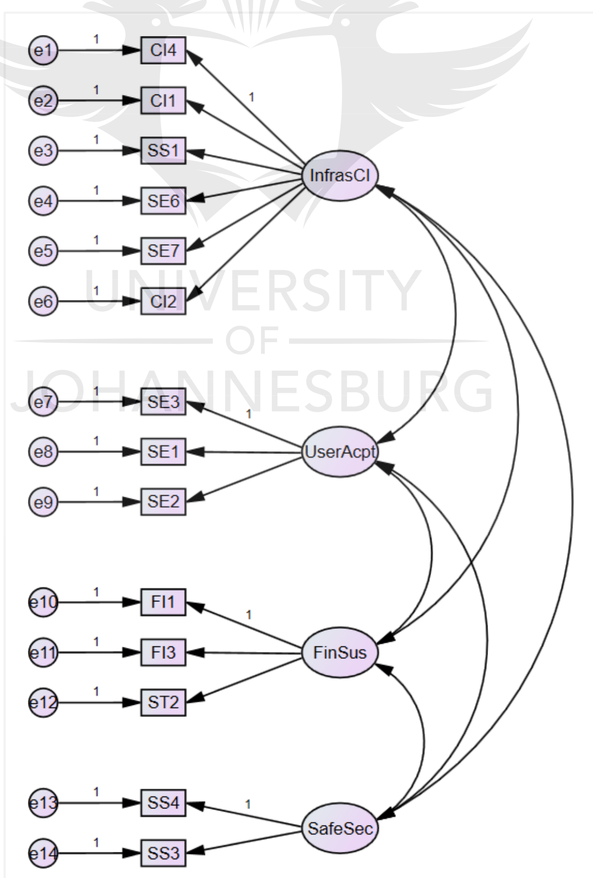


Figure 7.5: Theorised project sustainability model

Table 7.28: Project sustainability measures after EFA

S/No.	Measures	Label
Infrastructure condition and impacts	Infrastructure in its present condition is able to withstand common adverse weather	CI4
	The infrastructure is in good condition	CI1
	Signage for safety is adequate	SS1
	New business ventures have developed after the infrastructure was built	SE6
	Infrastructure is accessible by all including the disabled and elderly	SE7
	There are no complaints about the cleanliness of the infrastructure	CI2
User acceptability	There are no complaints about inconvenience during travel	SE3
	There are no complaints about travel times	SE1
	There are no complaints about user discomfort during travel	SE2
Financial sustainability	Capital invested has been recovered	FI1
	There are no complaints from investors about revenue	FI3
	Users are satisfied with pricing charges	ST2
Safety and security	Security cameras are in place	SS4
	Security officers are visible	SS3

Initial PS model fit analysis

The initial evaluation of the PS input model showed that there were no high correlations (exceeding 0.80) between the latent constructs (see appendix XV-A). This indicated that there was discriminant validity for the PS input model.

The model fit indices for the first run (Table 7.29) showed that the chi-square was significant (p=0.000), indicating that the postulated model was significantly different from the sample data. Other indices revealed that CMIN/*df* = 2.860 (cut-off value = ≤ 2 or 3), CFI = 0.888 (cut-off value = ≥ 0.90), SRMR = 0.0687 (cut-off value = > 0.05 to 0.08), and RMSEA = 0.122 (cut-off value = 0.09). The CFI and RMSEA values indicated that the hypothesised model did not match the data. However, the SRMR, which informs on the degree of discrepancy between the hypothesised model and the sample data, was acceptable, indicating that the PS input model matched the data. Nevertheless, an examination of other output from this first run was undertaken to determine if the model fit could be improved.

Table 7.29: Fit indices for PS input model

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		203.084	
Degrees of freedom *df*	> 0 ; positive	71	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.860	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.888	Not acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.0687	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.122	Not acceptable

Diagnostic fit analysis

Initial diagnostic analysis was undertaken by examining the output from the standardised residuals covariance matrix (Appendix XV-B). As can be seen, there were no high residual covariances among items in the input model. Residual covariance values should not be above 2.58 (Byrne, 2006; Musonda, 2012). However, SE6 covaried with four other items in the model with values more than 1.0. Likewise, SSI covaried with three other items with values greater than 1.0. These items were deleted successively.

Model modification

With the evidence from the diagnostic analysis, SE6 and SS1 were deleted one after the other. The model fit indices (Table 7.30) showed the results after each deletion. It was notable that the model fit improved significantly after the third run with CMIN/df = 1.986, falling below the recommended 2.0, CFI = 0.949, close to 0.95 (cut-off value > 0.90), RMSEA = 0.089 (cut-off value = < 0.09), and SRMR = 0.0586 (cut-off value > 0.05 to 0.08). Based on the two-index presentation strategy advocated by Hu and Bentler (1999), this model was observed to be an excellent fit to the sample data.

Table 7.30: Model fit indices – PS model

Fit indices	Cut off value	2nd run (SE6 removed)	3rd run (SS1 removed)
χ^2		156.572	95.349
df	> 0 ; positive	59	48
CMIN/*df*	≤ 2 or 3	2.654	1.986
CFI	Close to 0.95; ≥ 0.90	0.909	0.949
SRMR	> 0.05 to 0.08	0.0640	0.0586
RMSEA	< 0.09 – good fit < 1.0 – reasonable fit	0.115	0.089

However, the item ST2 was found to have a low contribution of 34% (Appendix XV-C). This indicated that the item was contributing more error variance than explained variance in the model. It therefore had to be removed before structural modelling. The item ST2 was therefore removed and the test rerun. The final model displayed acceptable fit (Table 7.31), with values within the recommended ranges: CMIN/df = 2.087 (cut-off value < 2 or 3), CFI= 0.95 (cut-off value > 0.90), RMSEA = 0.094 (cut-off value 0.09), and SRMR = 0.0570 (cut-off value > 0.05 to 0.08). These results indicated that the hypothesised PS model matched the sample data by 95% and with a residual value of 5.7%, the model can be deemed to be an excellent fit to the data. It was notable that approximately 20% of the number of items (three out of 14) were deleted, and this was observed to be permissible in a model-generating CFA (Byrne, 2001; Awang, 2012).

Table 7.31: Model fit indices for selected PS model

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		85.579	
Degrees of freedom *df*	> 0 ; positive	41	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.087	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.950	Acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.0570	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.094	Acceptable

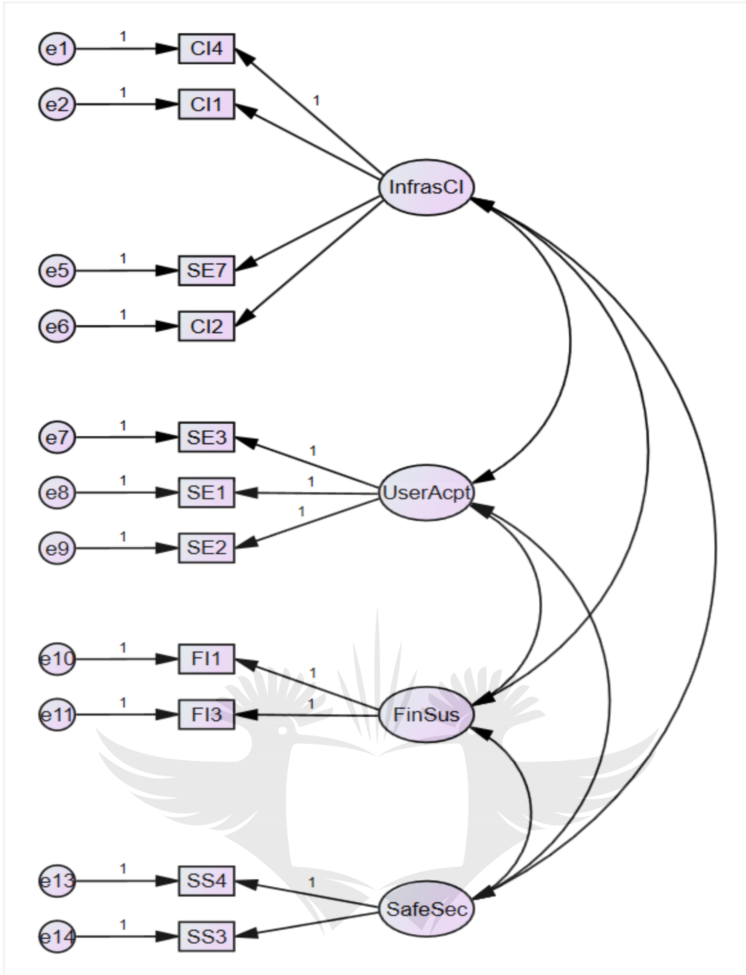


Figure 7.6: Selected PS measurement model

Statistical significance of the PS parameter estimates

An examination of the factor loadings (regression weights), standard errors and critical ratio estimates were undertaken to determine if the model parameters were statistically significant (Byrne, 2006). The PS final measurement model parameters exhibited statistical significance with the squared multiple correlations values all less than or equal to 1.0 and therefore reasonable. The parameter estimates had high correlation values (above 0.4). The correlation values suggested a high degree of linear association between the indicator variables and their latent constructs, and therefore reasonable.

In addition, the critical ratio test statistic, analogous to *Z* scores, was used to test the significance of the parameters. The critical ratio, which is the parameter estimate divided by its standard error, had to be greater than 1.96 at the 0.05 significance level for it to be said to be statistically different from zero and considered significant. Table 7.32, containing the parameter estimates, showed that the critical ratio values were all above 1.96 and therefore statistically significant.

Table 7.32: Parameter estimates of the selected PS measurement model

Latent construct	Variable	Squared multiple correlations R^2	Factor loading (unstandardised λ)	Factor loading (standardised λ)	Critical ratio	Significant at 0.05 level?
Infrastructure condition and impacts	CI4	.559	1.000	.748	…	Yes
	CI1	.633	.972	.795	8.645	Yes
	SE7	.442	.822	.665	7.174	Yes
	CI2	.705	1.150	.839	9.100	Yes
User Acceptability	SE3	1.000	1.000	1.000	…	Yes
	SE1	.773	1.000	.879	…	Yes
	SE2	.808	1.000	.899	…	Yes
Financial sustainability	FI1	.548	1.000	.740	…	Yes
	FI3	.622	1.000	.789	…	Yes
Safety and security	SS4	.689	1.000	.830	…	Yes
	SS3	.717	.871	.847	7.454	Yes

… Values not determined due to unstandardised regression weight of 1.0

Reliability and validity of the project sustainability measurement model

The reliability of the measurement model for project sustainability was evaluated using the formulae for CR and AVE tests (Equations 7.5 and 7.6). Table 7.33 indicated that the required levels of composite reliability and average variance extracted were met as they exceeded recommended thresholds. Composite reliability values should exceed 0.6 and average variance extracted values should be above 0.5 (Awang, 2012).

$$\mathrm{CR} = \frac{(\Sigma\lambda_j)^2}{[(\Sigma\lambda_j)^2 + \Sigma(1-\lambda_j^2)]}$$

Equation 7.5

$$\mathrm{AVE} = \frac{\sum \lambda_i^2}{n}$$

Equation 7.6

where λ is the factor loading, and *n* is the number of items in the model.

Convergent validity was achieved by the AVE values all being above 0.5 (Table 7.33). Construct validity was achieved by the model being of good fit, with all the fit indices within the recommended cut-off ranges. Discriminant validity was achieved by the modification indices being below 15 and the inter-construct correlations were lower than 0.85.

Table 7.33: Reliability results for selected PS measurement model

Latent construct	**Item**	**Factor loading λ**	**CR (> 0.6)**	**AVE (> 0.5)**	**Comment**
Infrastructure condition and impacts (n = 4)	CI4	.748	0.762	0.585	Required level was achieved
	CI1	.795			
	SE7	.665			
	CI2	.839			
User acceptability (n = 3)	SE3	1.000	0.926	0.860	Required level was achieved
	SE1	.879			
	SE2	.899			
Financial sustainability (n = 2)	FI1	.740	0.765	0.586	Required level was achieved
	FI3	.789			
Safety and security (n = 2)	SS4	.830	0.839	0.703	Required level was achieved
	SS3	.847			

Furthermore, discriminant validity was achieved by the inter-construct correlation values being below the square root of the AVEs, as shown in Table 7.34. The table showed the diagonals in bold, which are the square root values of the AVE for the constructs, and the other values in rows and column are the correlation between the constructs related. The square root of the AVE values should be greater than the inter-construct correlations for discriminant validity to be achieved (Awang, 2012).

Table 7.34: Discriminant validity for PS measurement models

Construct	Infrastructure condition and impacts	User acceptability	Financial sustainability	Safety and security
Infrastructure condition and impacts	**0.76**			
User acceptability	0.57	**0.93**		
Financial sustainability	0.73	0.44	**0.77**	
Safety and security	0.63	0.46	0.46	**0.84**

In summary, in this section, the variables which freely loaded on respective latent constructs for TIFS, FQ and PS were determined. Using a model generating approach to CFA, the primary focus was to generate a measurement model that best described the sample data, and as such modifications were necessary based on the sources of misfit identified (Byrne, 2001:7). Therefore, based on the above discourse, as well as the reliability and validity tests, the validated measurement models were deemed reliable and valid for structural modeling. The next section presents the structural models evaluated in the study.

7.5.3 The structural modeling

Having determined the measurement models, the adequacy of their goodness of fit, as well as reliability and validity, the structural model (Figure 7.7) was used to test the hypotheses postulated in the current study. The essence of the SEM was to determine interrelationships between the latent constructs (Schreiber *et al.*, 2006). The SEM sought to test the hypothesized model to capture the relationships among the validated latent constructs, based on theoretical, practical and statistical considerations. The sample of 125 cases with imputed data (no missing data) was used for structural modeling.

The full latent model (Appendix XVI-A) was constructed with all the relationships (direct and indirect) interrelations among latent constructs and observable variables in the model as a succession of structural equations, similar to running several regression equations (Schreiber *et al.*, 2006:325). The model was recursive in the sense that the causal relationships were all in one direction (Byrne, 2001). Circles represent latent variables while rectangles represent measured variables. The links (one-headed arrows) show the hypothesised relationships as imputed in AMOS, manually, using the validated measurement models for feasibility study elements, feasibility study quality and project sustainability. Prior to the hypotheses testing, the fit of the full latent model was examined and the results were presented hereunder. However, the hypothesised relationships were tested individually. The full latent model was disintegrated for the mere purpose of simplicity. Moreover, it was necessary to establish the direct effects separately, before applying bootstrapping to obtain the indirect results.

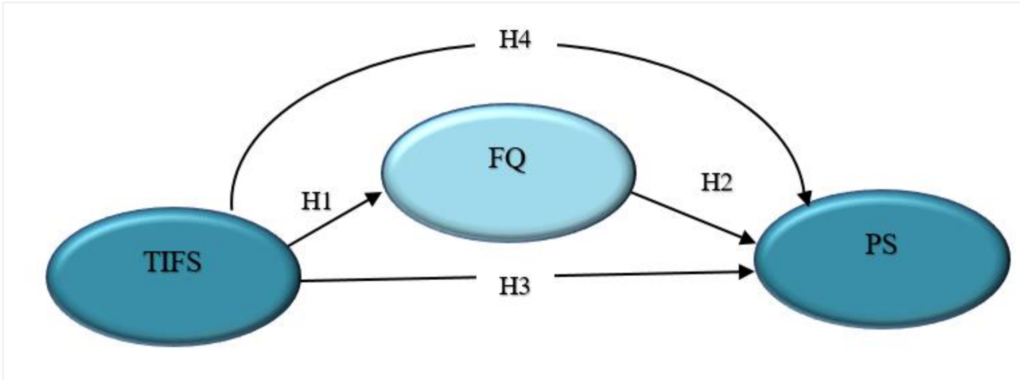


Figure 7.7: The structural model

7.5.3.1 Model fit analysis for the full latent model

The results of the measurement models indicated that they matched the sample data very well. Analysing the measurement models first with modifications using the model-generating approach was important since it established reliable and validated models which could be used in structural modeling. A non-valid model cannot be used in a structural model (Morrison *et al.*, 2017). Further, the researcher avoided the frustration of re-specifying the full latent model if a solution was not obtained (Musonda, 2012:213). Therefore, post-hoc modifications were not necessary since the aim at this stage, was to test the hypotheses with the measurement models generated and validated in the CFA procedure. Model improvement was not necessary as it was deemed to add little or no value to that already fitted and validated.

Consequently, it was feasible to test the full latent model. The model fit indices for the full latent model were presented in Table 7.35. The chi-square test value was significant (p=0.000) with the sample of 125 cases. The CMIN/*df* = 2.100 was within the acceptable range and thus indicating a good fit with the sample data. Although the CFI = 0.835, which was slightly below the generally recommended threshold of 0.90, it was fairly acceptable (Zen, 2007; Abedi *et al.*, 2010). Moreover, the absolute fit indices, SRMR = 0.0709 (cut-off value > 0.05 – 0.08) and RMSEA = 0.094 were within acceptable ranges. Therefore, based on Hu and Bentler's two-index presentation strategy, the model was deemed acceptable.

Table 7.35: Model fit indices for the full latent model

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		1056.103	
Degrees of freedom *df*	> 0 ; positive	503	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.100	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.835	Barely acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.0709	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.094	Acceptable

Following the establishment of a valid structural model, the hypotheses were tested based on the relationships espoused. The following broad hypotheses were posed for testing using structural modeling:

- TIFS has a direct influence on FQ (H1);
- FQ has a direct influence on PS (H2);
- TIFS has a direct influence on PS (H3); and
- TIFS has an indirect influence on PS (H4).

The hypotheses (null) were rejected based on the results of the standardised regression coefficients (**λ**), which showed the extent of the direct relationships between the latent variables considered (Schreiber *et al.*, 2006). The statistical significance of direct estimates for the respective paths was determined by the critical ratio coefficient (C.R.), which is the unstandardised parameter estimate divided by its standard error (S.E.) (Musonda, 2012). The C.R. coefficient had to be greater than or equal to 1.96 to assume significance at the 0.05 level for the null hypotheses H_0, that there is no influence, to be rejected (Byrne, 2001). In addition, the indirect effects were reported for the H4 model. The significance of the indirect effects was set at p > 0.05 level. A 95% confidence interval was set using bootstrapping to establish the indirect effects.

7.5.3.2 Hypothesis 1 – Direct influence of transportation feasibility study (TIFS) factors on the quality of feasibility studies (FQ)

The first hypothesis, H1, postulated that transportation infrastructure feasibility studies (TIFS) had a direct influence on the quality of feasibility studies (FQ) in terms of the people and processes involved. The model in Figure 7.8 represented the relationships hypothesised. The tested model was presented in Appendix XVI-B.

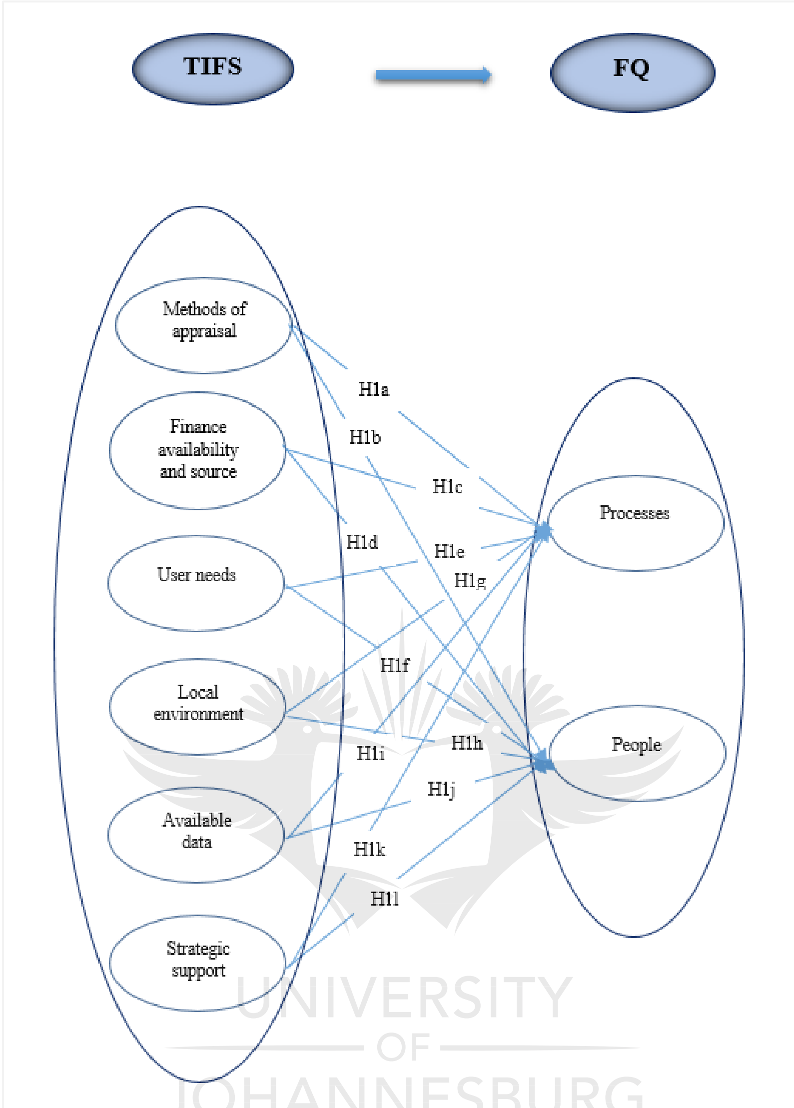


Figure 7.8: Hypothesis 1 model - Direct influence of TIFS on FQ

Model fit analysis for H1 model

The fit statistics for the H1 model showed that the model was acceptable. The results presented in Table 7.36 were $\chi 2$ = 444.934, *df* = 224, CMIN/*df* =1.986 (cut-off value < 2 or 3), CFI =0.893 (cut-off value ≥ 0.90), SRMR = 0.0768 (> 0.05 to 0.08), and RMSEA = 0.089 (cut-off value < 0.09). With the CFI index approximately at the limit value of 0.90 for model acceptance, and the SRMR and RMSEA within the cut-off limits, the model was deemed an adequate fit to the sample data. The postulated hypotheses were subsequently tested.

Table 7.36: Model fit indices for Model H1

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		444.934	
Degrees of freedom *df*	> 0 ; positive	224	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	1.986	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.893	Acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.076	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.089	Acceptable

Hypotheses testing – Model H1

The null hypothesis for Model H1 generally postulated that the TIFS factors had no direct influence on the quality of feasibility studies. Specifically, the null hypotheses postulated were that:

1. Methods of appraisal had no direct influence on the processes followed in feasibility studies (*H1a*);
2. Methods of appraisal had no direct influence on the people involved in feasibility studies (*H1b*);
3. Finance availability and source had no direct influence on the processes followed in feasibility studies (*H1c*);
4. Finance availability and source had no direct influence on the people involved in feasibility studies (*H1d*);
5. User needs considered had no direct influence on the processes followed in feasibility studies (*H1e*);
6. User needs considered had no direct influence on the people involved in feasibility studies (*H1f*);
7. Local environment considered had no direct influence on the processes followed in feasibility studies (*H1g*);
8. Local environment considered had no direct influence on the people involved in feasibility studies (*H1h*);
9. Available data had no direct influence on the processes followed in feasibility studies (*H1i*
10. Available data had no direct influence on the people involved in feasibility studies (*H1j*);

11. Strategic support had no direct influence on the processes followed in feasibility studies (*H1k*); and
12. Strategic support had no direct influence on the people involved in feasibility studies (*H1l*).

Results from the SEM analysis on the above hypothesised relationships were presented in Table 7.37. The hypothesised relationships with regard to methods of appraisal, finance availability and source, available data and strategic support were found to be significant on the quality of feasibility studies in terms of processes and people involved. The relationship between methods of appraisal and the people involved was the most significant (λ = 0.497, CR=4.316, p = 0.000), indicating that the more the methods of appraisal considered, the higher the variety of people that should be involved to ensure that every aspect of the investment is covered during the feasibility assessment.

The relationship between strategic support and the processes employed in feasibility studies (λ = 0.397, CR=2.422, p = 0.000) was also found to be significant. The regression weight for strategic support factor in the prediction of processes involved was significantly different from zero at the 0.05 level. This coefficient was positive, indicating that the higher the attention given to strategic support for the project at the feasibility stage, the more the processes which would be employed to ensure that strategic support for the project, from start to finish and even beyond, is available.

Similarly, the hypothesised relationships between the factor available data and processes as well as people were found to be significant. The direct effects, on people (λ = 0.349, CR=4.083, p = 0.000), and processes (λ = 0.251, CR=2.972, p = 0.003), indicated that the higher the volume and type of data available, the more processes and people that would be involved in addressing different aspects the projects, during the feasibility studies.

Likewise, the parameter coefficients for the influence of finance availability and sources on the processes employed were significant at the 0.05 level of significance (λ = 0.261, CR = 2.372, p=0.018). It was notable that this relationship was positive, indicating that the higher the consideration given to sources of finance for the project, the more the involvement of a variety of people to ensure that the feasibility study comprehensively includes the necessary information needed to make decisions regarding the proposed investment.

On the other hand, the influence of the factors user needs and local environment on the quality of feasibility studies were not found to be significant at the 5% probability level. These relationships, user needs and processes (**λ** = -0.030, CR=-0.329, p = 0.742), user needs and people (**λ** = 0.013, CR=0.150, p = 0.880), local environment and processes (**λ** = 0.162, CR=1.387, p = 0.166), and local environment and people (**λ** = 0.063, CR=0.573, p = 0.567), yielded too little regression weights and were thus not significant. Therefore, the specific null hypotheses, *H1e* to *H1h* were supported and thus could not be rejected.

Table 7.37: Model H1 factor loadings and significance statistics

Model H1			**Factor loading λ**	**Critical ratio *CR***	***P* value**	**Statistically significant?**
H1a	Methods of	Processes	-.117	-1.042	.297	No
H1b	appraisal →	People	.497	4.316	.000	Yes
H1c	Finance availability	Processes	.261	2.372	.018	Yes
H1d	and source →	People	.189	1.856	.063	No
H1e	User needs →	Processes	-.030	-.329	.742	No
H1f		People	.013	.150	.880	No
H1g	Local	Processes	.162	1.387	.166	No
H1h	environment →	People	.063	.573	.567	No
H1i	Available data →	Processes	.251	2.972	.003	Yes
H1j		People	.349	4.083	.000	Yes
H1k	Strategic support →	Processes	.397	2.422	.015	Yes
H1l		People	.003	.023	.982	No

Solution evaluation of the H1 path in structural model

The fit indices of the CFI, SRMR and RMSEA for the H1 model were all within the recommended thresholds and thus acceptable. The parameter estimates were statistically significant and the factor loadings were medium-ranged, except for the influence of methods of appraisal on people involved which was large. Therefore, given that some of the hypothesised relationships were significant, the general null hypothesis that TIFS had no direct influence on FQ may be rejected.

Moreover, the H1 path was tested using the full structural model (Appendix XVI-E). The results (λ=0.604, CR=4.611, p=0.000) presented in Table 7.38 indicated that the direct influence of TIFS on FQ was significant. The impact significance was found to be large and positive. Therefore, the general null hypothesis may be rejected.

Table 7.38: H1 path results using the full structural model

Model H1			Factor loading λ	Critical ratio *CR*	*P* value	Statistically significant?
H1 path	TIFS →	FQ	0.604	4.611	0.000	Yes

7.5.3.3 Hypothesis 2 – Direct influence of feasibility study quality (FQ) on project sustainability (PS)

The second hypothesis, H2, postulated that the quality of feasibility studies, in terms of the people involved and the processes employed, had a direct influence on the sustainable performance of transportation infrastructure projects. Figure 7.9 displayed the relationships postulated to be tested. The tested model was presented in Appendix XVI-C.

Model fit analysis for H2 model

The fit statistics for the H1 model (Table 7.39) showed that the model was acceptable. The results were $\chi 2$ = 270.957, *df* = 112, CMIN/*df* =2.419 (cut-off value < 2 or 3), CFI =0.887 (cut-off value ≥ 0.90), SRMR = 0.0741 (> 0.05 to 0.08), and RMSEA = 0.107 (cut-off value < 0.09). The relative chi-square was below the recommended value of 3.0, and thus indicating good model fit. The CFI index was close to the recommended value of 0.90 for model acceptance, and thus was fairly acceptable; while the SRMR was within the acceptable limit indicating good model fit. Therefore, based on the two-index approach proposed by Hu and Bentler (1999), the H2 model was deemed to be acceptable with 89% CFI fit and 7% residual fit.

Moreover, since the full latent model demonstrated an acceptable fit, no post-hoc modifications were necessary. In addition, the goal at this stage was to test the hypotheses, and this was subsequently done.

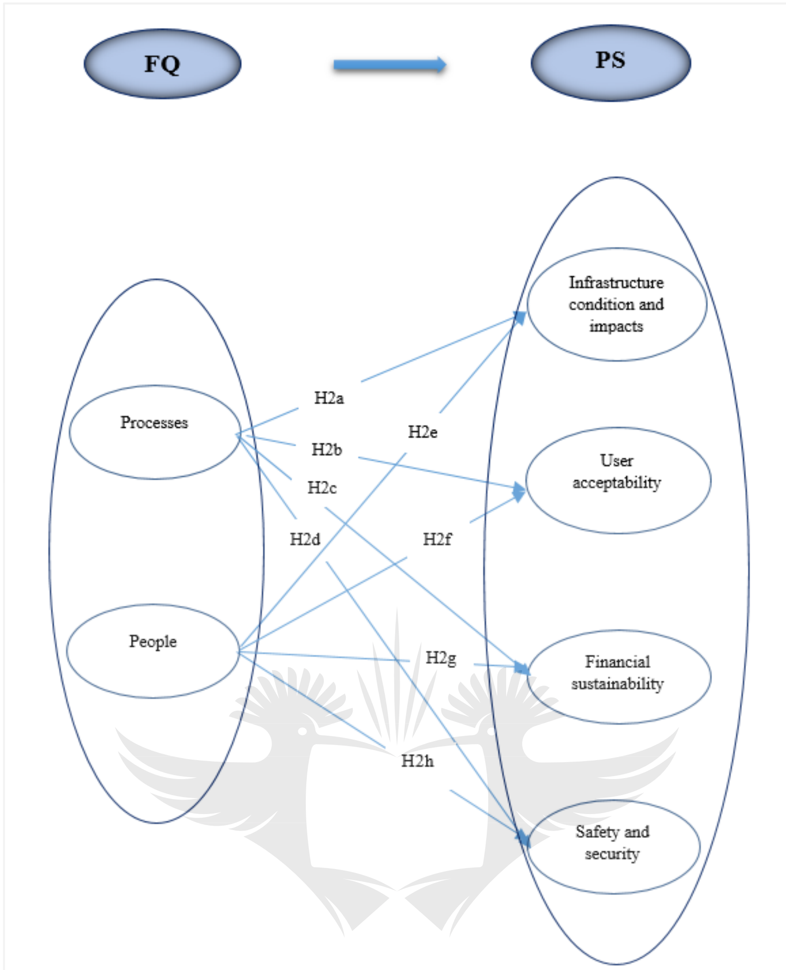


Figure 7.9: Hypothesis 2 model - Direct influence of FQ on PS

Table 7.39: Model fit indices for Model H2

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		444.934	
Degrees of freedom *df*	> 0 ; positive	224	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	1.986	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.893	Acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.076	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.089	Acceptable

Hypotheses testing – Model H2

For model H2, the general null hypothesis postulated that the quality of feasibility studies had no direct influence on the sustainable performance of transportation projects while in operation. Specifically, the null hypotheses postulated that:

1. Processes followed had no direct influence on infrastructure condition and impacts (*H2a*);
2. Processes followed had no direct influence on user acceptability (*H2b*);
3. Processes followed had no direct influence on financial sustainability (*H2c*);
4. Processes followed had no direct influence on safety and security (*H2d*).
5. People involved had no direct influence on infrastructure condition and impacts (*H2e*);
6. People involved had no direct influence on user acceptability (*H2f*);
7. People involved had no direct influence on financial sustainability (*H2g*);
8. People involved had no direct influence on safety and security (*H2h*);

The results of the SEM analysis for the H2 model were presented in Table 7.40. The table evinced that the relationships between people and all the project sustainability indicators were significant, with the highest influence on infrastructure condition and impacts (λ = 1.482, CR=3.655, p = 0.000), followed by financial sustainability (λ = 0.943, CR=3.613, p = 0.000), safety and security (λ = 0.860, CR=3.377, p = 0.000), and then user acceptability (λ = 0.586, CR=3.154, p = 0.002). These relationships were large and positive implying that the higher the involvement of relevant people in feasibility studies at the initial stage of projects, the more sustainable the projects would be.

On the other hand, non-significant relationships were found between processes employed and project sustainability. Although the influence on infrastructure conditions and impacts was large, the relationship was negative and statistically insignificant. The magnitude of the relations between processes and financial sustainability as well as safety and security were medium and negative, implying that an increase in the extent of adherence to procedures in feasibility studies would result to a decrease in performance. However, these relations were not significant and therefore the related null hypotheses could not be rejected. Nonetheless, the general hypothesis that FQ has a direct influence on PS was statistically supported using the full structural model (Appendix XVI-E). Therefore, the general null hypothesis may be rejected.

Table 7.40: Model H2 factor loadings and significance statistics

	Model H2		Factor loading λ	Critical ratio *Z*	*P* value	Statistically significant?
H2a	Processes →	Infrastructure condition and impacts	-.647	-1.904	.057	No
H2b		User acceptability	.014	.078	.937	No
H2c		Financial sustainability	-.335	-1.398	.162	No
H2d		Safety and security	-.334	-1.473	.141	No
H2e	People →	Infrastructure condition and impacts	1.482	3.655	.000	Yes
H2f		User acceptability	.586	3.154	.002	Yes
H2g		Financial sustainability	.943	3.613	.000	Yes
H2h		Safety and security	.860	3.377	.000	Yes

Solution evaluation of the H2 path in structural model

The fit indices of the CFI, SRMR and RMSEA were all acceptable for the H2 model. Four relationships were found to be statistically significant and thus it was deemed that the quality of feasibility studies had an influence on project sustainability, to the extent of the people involved.

However, the testing of the H2 path (influence of FQ on PS) using the full structural model indicated that there was significant relationship between the FQ and PS. The results presented in Table 7.41 (λ=0.351, CR=3.468, p=0.000) indicated that the direct effect of FQ on PS was medium and positive, indicating that the higher the quality of the feasibility study, the better the project performance. Therefore, the general null hypothesis for the H2 path may be rejected.

Table 7.41: H2 path results using the full structural model

Model H2				Factor loading λ	Critical ratio *CR*	*P* value	Statistically significant?
H2 path	FQ	→	PS	0.351	3.468	0.000	Yes

7.5.3.4 Hypothesis 3 – Direct influence of transportation infrastructure feasibility study (TIFS) on project sustainability (PS)

The third hypothesis, H3, postulated that transportation infrastructure feasibility study had a direct influence on the sustainable performance of transportation infrastructure projects. Figure 7.10 displayed the relationships postulated to be tested. The tested model was presented in Appendix XVI-D.

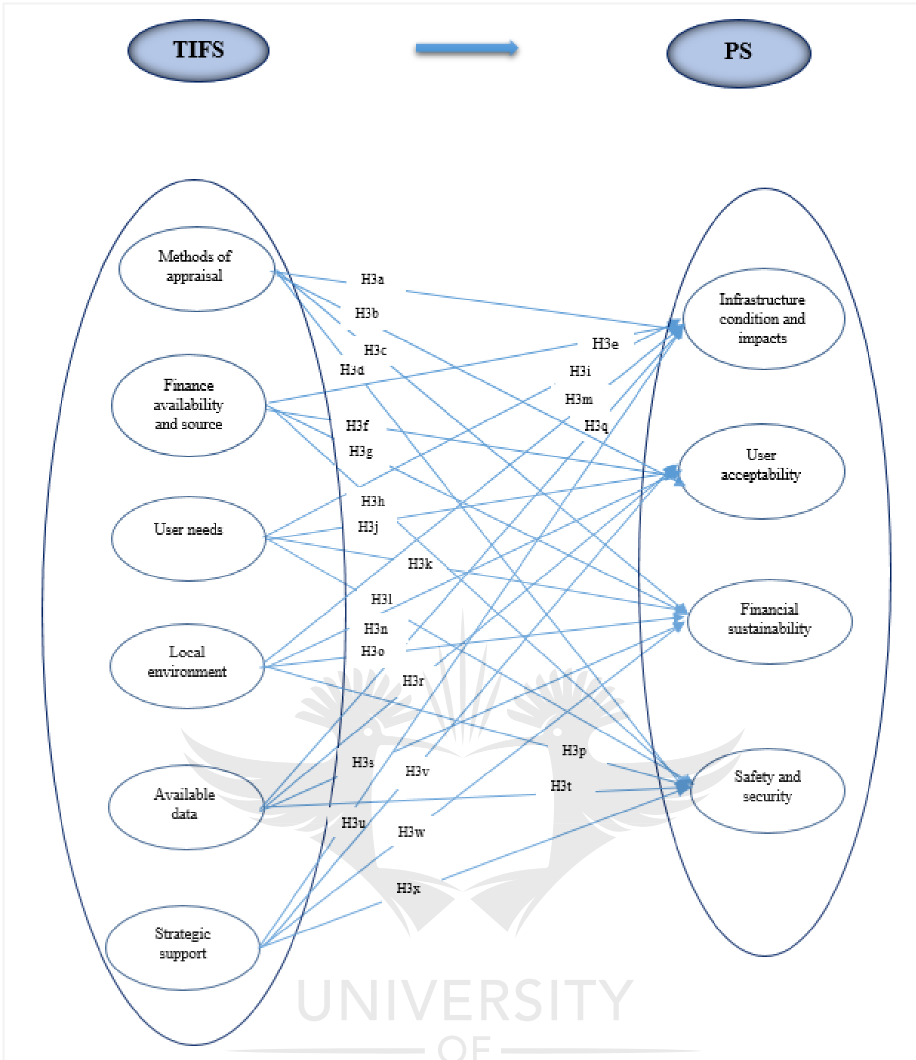


Figure 7.10: Hypothesis 3 model - Direct influence of TIFS on PS

Model fit analysis for H3 model

The fit analysis results (Table 7.42) for the H3 model showed that the model matched the data. The relative chi-square (CMIN/*df)* was below the recommended upper value of 3.0; CFI = 0.857 (which was not far from the recommended value of 0.90 for model acceptance), the acceptable SRMR of 0.0726 and the RMSEA of 0.095 (which was slightly above the lower limit of 0.09 cut-off value). These results indicated that the model was acceptable with 86% model fit (CFI) and 7% residual or remaining fit as the SRMR suggested. Moreover, based on the two-index presentation strategy proposed by Hu and Bentler (1999), the model was deemed to adequately match the sample data. No post-hoc modifications were therefore undertaken to re-specify or modify the H3 model. The hypotheses testing ensured.

Table 7.42: Model fit indices for Model H3

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		723.286	
Degrees of freedom *df*	> 0 ; positive	341	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.121	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.857	Barely acceptable
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.0726	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.095	Acceptable

Hypotheses testing – Model H3

For model H3, the general null hypothesis postulated that transportation infrastructure feasibility studies had no direct influence on the sustainable performance of transportation projects while in operation. Specifically, the null hypotheses postulated that:

1. Methods of appraisal had no direct influence on infrastructure condition and impacts (*H3a*);
2. Methods of appraisal had no direct influence on user acceptability (*H3b*);
3. Methods of appraisal had no direct influence on financial sustainability (*H3c*);
4. Methods of appraisal had no direct influence on safety and security (*H3d*).
5. Finance availability and source considered had no direct influence on infrastructure condition and impacts (*H3e*);
6. Finance availability and source considered had no direct influence on user acceptability (*H3f*);
7. Finance availability and source considered had no direct influence on financial sustainability (*H3g*);
8. Finance availability and source considered had no direct influence on safety and security (*H3h*);
9. User needs considered had no direct influence on infrastructure condition and impacts (*H3i*);

10. User needs considered had no direct influence on user acceptability (*H3j*);
11. User needs considered had no direct influence on financial sustainability (*H3k*);
12. User needs considered had no direct influence on safety and security (*H3l*).
13. Local environment considered had no direct influence on infrastructure condition and impacts (*H3m*);
14. Local environment considered had no direct influence on user acceptability (*H3n*);
15. Local environment considered had no direct influence on financial sustainability (*H3o*);
16. Local environment considered had no direct influence on safety and security (*H3p*);
17. Available data had no direct influence on infrastructure condition and impacts (*H3q*);
18. Available data had no direct influence on user acceptability (*H3r*);
19. Available data had no direct influence on financial sustainability (*H3s*);
20. Available data had no direct influence on safety and security (*H3t*).
21. Strategic support considered had no direct influence on infrastructure condition and impacts (*H3u*);
22. Strategic support considered had no direct influence on user acceptability (*H3v*);
23. Strategic support considered had no direct influence on financial sustainability (*H3w*); and
24. Strategic support considered had no direct influence on safety and security (*H3x*).

The results of the SEM analysis for the H3 model were presented in Table 7.43. The table showed that there was a significant relationship between strategic support and all the project sustainability indicators, with the effects highest on infrastructure condition and impacts (λ=2.164, CR=2.882, p=0.004), followed by safety and security (λ=2.115, CR=2.717, p=0.007), financial sustainability (λ=1.818, CR=2.837, p=0.005) and then user acceptability (λ = 1.735, CR=2.759, p = 0.006). These effects were large and positive, suggesting that more attention to strategic support for the project during feasibility studies would result in better performance at the operational stage of projects.

Similarly, large significant direct effects were found between financial availability and sources and infrastructure condition and impacts (λ=-0.870, CR=-2.089, p=0.037), user acceptability (λ =-0.730, CR=-2.045, p=0.041), and safety and security (λ=0.953, CR=-2.171, p=0.030). The direct influence of financial availability and sources on financial sustainability was not significant, surprisingly.

The influence of user needs on financial sustainability was found to be statistically significant (λ=-0.469, CR=-1.987, p=0.047), albeit negative; while other relationships hypothesised for user needs were not significant. The hypothesised relationships with regard to methods of appraisal, local environment, and available data did not yield statistically significant results. Therefore, the specific null hypotheses related to these may not be rejected.

Table 7.43: Model H3 factor loadings and significance statistics

	Model H3		**Factor loading λ**	**Critical ratio *Z***	***P* value**	**Statistically significant?**
H3a	Methods of appraisal →	Infrastructure condition and impacts	-.211	-.807	.420	No
H3b		User acceptability	-.242	-1.047	.295	No
H3c		Financial sustainability	-.362	-1.529	.126	No
H3d		Safety and security	-.262	-.945	.345	No
H3e	Finance availability and source considered →	Infrastructure condition and impacts	-.870	-2.089	.037	Yes
H3f		User acceptability	-.730	-2.045	.041	Yes
H3g		Financial sustainability	-.245	-.693	.488	No
H3h		Safety and security	-.953	-2.171	.030	Yes
H3i	User needs considered →	Infrastructure condition and impacts	-.480	-1.809	.070	No
H3j		User acceptability	-.324	-1.419	.156	No
H3k		Financial sustainability	-.469	-1.987	.047	Yes
H3l		Safety and security	-.487	-1.748	.080	No
H3m	Local environment considered →	Infrastructure condition and impacts	-.454	-1.266	.205	No
H3n		User acceptability	-.419	-1.333	.183	No
H3o		Financial sustainability	-.588	-1.823	.068	No
H3p		Safety and security	-.755	-1.947	.052	No
H3q	Available data →	Infrastructure condition and impacts	.252	1.398	.162	No
H3r		User acceptability	-.004	-.026	.979	No
H3s		Financial sustainability	.216	1.321	.186	No
H3t		Safety and security	.264	1.367	.172	No
H3u	Strategic support considered →	Infrastructure condition and impacts	2.164	2.882	.004	Yes
H3v		User acceptability	1.735	2.759	.006	Yes
H3w		Financial sustainability	1.818	2.837	.005	Yes
H3x		Safety and security	2.115	2.717	.007	Yes

Solution evaluation of the H3 path in structural model

The fit indices of the SRMR and RMSEA were acceptable for the H3 model. The CFI, which was close to the recommended 0.09 at 0.857 was fairly acceptable. Therefore, the fit indices results showed that the H3 model matched the sample data. The model was not improved further in view of the goal of the analysis at the current stage, to test postulated hypothesis.

The individual testing of the H3 specific hypotheses revealed that seven of the parameter estimates of the model were statistically significant, with factor loadings ranging from medium to large direct effects. In addition, the testing of the direct influence of TIFS on PS (H3 path) using the full structural model (Appendix XVI-E) revealed that the effect was significant. The results presented in Table 7.44 showed that the effect was medium and positive (λ=0.467, CR=3.796, p=0.000). This suggested that the more comprehensive the feasibility study is, the better the project performance. Therefore, the general null hypothesis $H3_0$ that TIFS does not have a direct influence on PS may be rejected.

Table 7.44: H3 path results using the full structural model

Model H3				Factor loading λ	Critical ratio *CR*	*P* value	Statistically significant?
H3 path	TIFS	→	PS	0.467	3.796	0.000	Yes

7.5.3.5 Hypothesis 4 – Indirect influence of transportation infrastructure feasibility study (TIFS) on project sustainability (PS)

The fourth hypothesis, H4, postulated that transportation infrastructure feasibility study has an indirect influence on the sustainable performance of transportation infrastructure projects, mediated by the quality of feasibility studies, in terms of people and processes involved. An indirect effect between two variables exists if the direct relationship is completely insignificant or diminishes in the face of an increased direct significance (Musonda, 2012:230). The structural model (Appendix XVI-E) was bootstrapped in order to identify the indirect effects of TIFS on PS with 95% confidence interval.

Model fit analysis for H4 model

The fit analysis results (Table 7.45) for the bootstrapped model revealed that the model matched the data. The CMIN/*df* = 2.100, CFI = 0.835, RMSEA = 0.094 and SRMR = 0.0709. The relative chi-square was below the recommended upper value of 3.0 and thus acceptable. The SRMR of 0.0709 was indicative of a good fit and the RMSEA was below 1.0 indicating a reasonable fit. The CFI statistic fell slightly below the recommended value of 0.90 for model acceptance, but was observed to be liberal and fairly acceptable at 0.84. This meant that the model had an 84% fit with the sample data and a 7% residual fit, which was acceptable. Therefore, based on the two-index presentation strategy advocated by Hu and Bentler (1999), the model was observed to be acceptable and thus no further modifications were made.

Table 7.45: Model fit indices for Model H4

Fit indices	Cut off value	Estimate	Comment
Chi-square χ^2		1056.103	
Degrees of freedom *df*	> 0 ; positive	503	Acceptable
Relative chi-square (CMIN/*df*)	≤ 2 or 3	2.100	Acceptable
Comparative fit index (CFI)	≥ 0.90	0.835	Inadequate
Standardised root mean square residual (SRMR)	> 0.05 to 0.08	0.0709	Acceptable
Root mean square error of approximation (RMSEA)	< 0.09 – good fit < 1.0 – reasonable fit	0.094	Acceptable

Hypothesis testing – H4 path in structural model

For model H4, the general null hypothesis postulated that transportation infrastructure feasibility studies had no indirect influence on the sustainable performance of transportation projects. For the null hypotheses to be rejected, the indirect effect had to be significantly different from zero. In other words, if zero falls outside the lower and upper bound values, then there is significant indirect mediating effect and the null hypotheses may be rejected. On the other hand, if zero falls within the lower and upper bound limits, at the 95% confidence interval, then there is no significant indirect effect and the null hypotheses may not be rejected.

The full structural model (Appendix XVI-E) was used to test the H4 path. It was necessary to test the direct influence of TIFS on PS separately before adding FQ to the model. In addition, bootstrapping was applied in order to establish reliable indirect estimates.

The bootstrapped results (Table 7.46) evinced that the indirect effect was significant (0.212; p = 0.003). Although a small effect was found, the impact was positive and significant. This indicated that TIFS factors indirectly influence the sustainability of transportation infrastructure projects. Therefore, the mediating role of the quality of feasibility studies was confirmed. Hence, the general null hypothesis that TIFS had no indirect effect on project sustainability may be rejected.

Table 7.46: Path H4 bootstrapped standardised estimates

Model H4		Direct effect	Indirect effect	Total effects	Lower bound 95% CI	Upper bound 95% CI	*P* value for indirect effect	Statistically significant?
H4 path	TIFS → PS	0.467	0.212	0.678	0.089	0.443	0.003	Yes

7.6 CHAPTER SUMMARY

Results of analyses from the quantitative phase of the study were presented in this chapter. An exploratory factor analysis was undertaken to determine the underlying factor structures for the constructs TIFS, FQ and PS. The EFA findings revealed that TIFS could adequately be explained by six factors, namely, methods, finance availability and source, user needs, local environment, available data and strategic support. The quality of feasibility studies emerged as a two-factor structure: processes and people involved, while project sustainability yielded a four-factor structure including infrastructure condition and impacts, user acceptability, financial sustainability and safety and security.

The EFA common factor structures were further analysed using the model-generating CFA approach to establish the measurement models for structural modelling. Results on the validity and reliability of the measurement models were presented. The measurement model analysis supported that TIFS is a six-factor model as evinced by the model fit indices. Hence, the measurement models were observed to be valid and reliable for hypotheses testing.

The postulation for the overall model was that transportation infrastructure feasibility study (TIFS) factors had an influence on the quality of feasibility studies (FQ), which in turn influences the sustainability of projects (PS). The analysis was conducted by evaluating the relationships as they were postulated. However, since it was necessary to determine the direct effects separately before introducing the mediator in the model, to establish the indirect effects, the full structural model was bootstrapped at 95% confidence interval.

The findings were that the transportation infrastructure feasibility study (TIFS) factors considered had a direct effect on the quality of feasibility studies (FQ), measured by people involved and processes employed. Additionally, the quality of feasibility studies (FQ) was found to have a direct influence on project sustainability. Further, a significant direct effect was found between the TIFS factors and project sustainability. The indirect relationship between the TIFS factors and project sustainability that was mediated by the quality of feasibility studies, was also found to be significant. Figure 7.11 presents a summary of the hypothesised direct relationships which were significant based on the individual testing of the H1, H2 and H3 specific hypotheses, while Figure 7.12 presents the results from the testing of the general hypotheses H1 to H4 using the overall (full) structural model. These results are discussed in the next chapter.

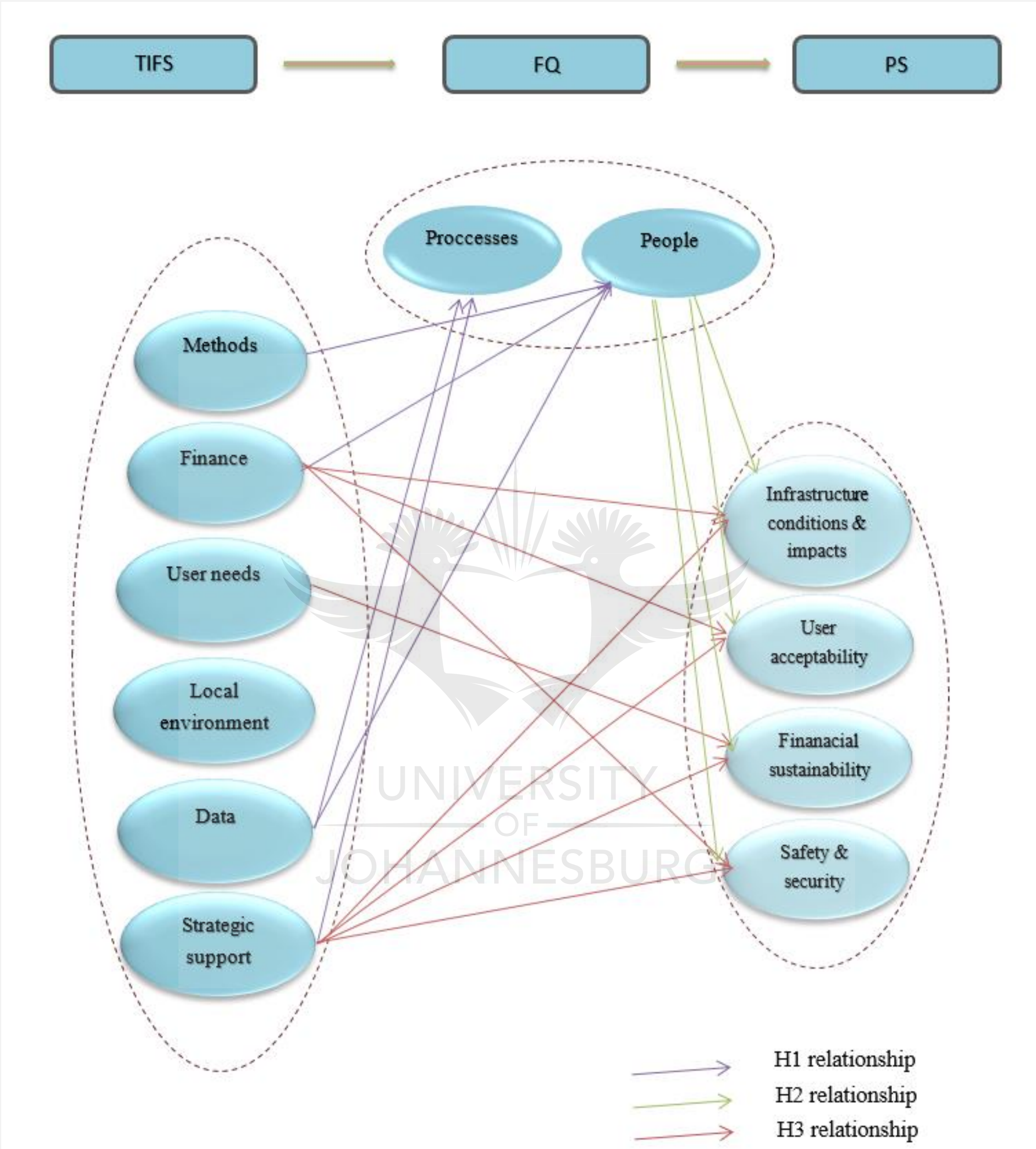


Figure 7.11: Findings on significant hypothesised H1, H2 and H3 (direct) relationships

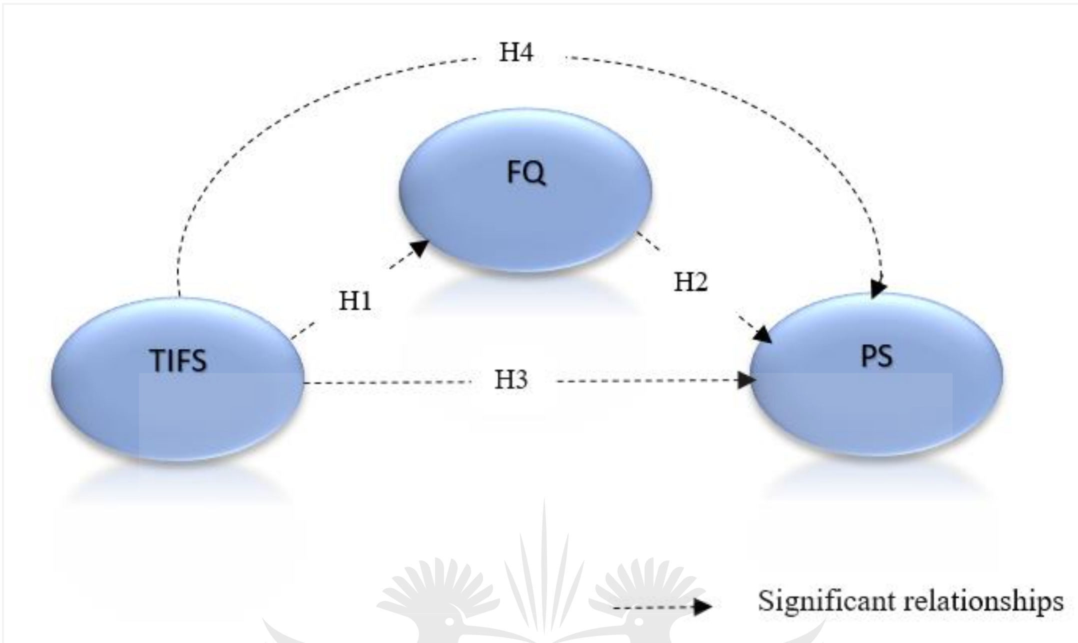


Figure 7.12: Findings on the overall (full) structural model

CHAPTER EIGHT

DISCUSSION OF RESULTS

8.1 INTRODUCTION

The current study sought to establish the critical factors which should be considered in a comprehensive feasibility study, as well as the influence of transportation infrastructure feasibility studies on project sustainability. The influence of the quality of feasibility studies defined by the people and processes, on project sustainability was evaluated. Additionally, the indirect influence of transportation infrastructure feasibility studies on project sustainability, with quality as the mediating factor, was investigated.

The current chapter discussed the results obtained from the quantitative analysis with regard to the study objectives. Reference was made to the qualitative phase findings as well as extant literature in the discourse.

8.2 CRITICAL FACTORS IN A COMPREHENSIVE FEASIBILITY STUDY

Findings from the descriptive analysis revealed that available planning data used in the feasibility studies of the sampled projects were mostly traffic counts, infrastructure master plans and international projects for benchmarking. The finding that traffic counts were considered the most important corresponds with the results from the case study investigation in which it was found that traffic data was relevant in monitoring and projecting future traffic patterns, as was evinced on seven of the eight projects studied (Table 5.3). Traffic data obtained from counts and surveys reflect the frequency and distribution, which are the bases of forecasts and determination of infrastructure size (Beria, 2007; Serero *et al.*, 2015).

Further, reference to infrastructure master plans was considered important in a comprehensive feasibility study as revealed from the descriptive findings. This is because integration of proposed networks with existing ones will be possible as was the case with the Addis Ababa light rail transit in Ethiopia (Nallet, 2018). However, infrastructure master plans were only referred to in two of the projects studied in the multi-case study phase, indicating inconsistence with Nallet's findings.

The finding that household income survey data was not considered important in the quantitative phase was supported by the case study findings, where household income survey data was considered on only one of the projects studies, the BRTs (Table 5.3). These findings did not align with an extant view that feasibility studies should reflect income earning opportunities and ability to pay the set travel charges (World Bank, 2005; Maunganidze and Del Mistro, 2012; Nallet, 2018).

With regard to feasibility study criteria factors considered on the sampled projects, the descriptive analyses indicated that safety, local conditions, existing infrastructure condition (for upgrade projects), as well as speed and travel time were considered the most prevalent factors as viewed by the questionnaire survey respondents. These factors were also considered important in the qualitative phase as evinced in Table 5.3, as well as in the EFA results, which showed that user benefits and needs (travel time savings, convenience, and comfort), infrastructure condition and safety were critical considerations in feasibility studies. These findings are consistent with extant studies which opined that due to the wide array of impacts that may materialise from transportation infrastructure projects, feasibility studies should unambiguously account for and accurately incorporate local conditions and environment, stakeholder interests as well as related factors including traffic fatality rates, value of personal time and safety benefits to users, which manifest either as infrastructure and user costs (Schutte and Brits, 2012; Cornett, 2016).

However, finance was deemed to be the least important factor in the quantitative findings. On the contrary, project funding was considered an important consideration on five of the eight projects studied in the multi-case study phase, and was also prominent in the EFA and CFA. Funding of projects should be considered in a comprehensive feasibility study since sufficient financial leverage is needed to implement investments with higher returns and benefits (Crescenzi *et al.*, 2016).

Further, the descriptive analyses revealed that the methods considered in a comprehensive feasibility study entail design and scope requirements, EIA, CBA, as well as site and locational characteristics. These results correspond, to an extent, with the multi-case study findings which revealed traffic modelling, analysis of alternatives, site and locational characteristics and scope requirements are important considerations in a comprehensive feasibility study. However, with the interpretation of factors in the EFA, traffic modelling cross-loaded on other factors, indicating high correlation with other factors and thus could not be used for further analysis. Nonetheless, the findings from the descriptive analysis correspond with the CFA results which validated that cost-benefits analysis (ME4), site/locational characteristics (ME5), as well as design and scope requirements (ME6) were important investment appraisal methods in feasibility studies (Figure 7.2). These findings were also in line with previous studies, which identified investment appraisal methods used in transportation infrastructure feasibility studies (Beria, 2007; Cervero, 2011; Jones *et al.*, 2014).

Conversely, the *rate of return on investment* and *the financial alternatives relative to costs* were not considered important appraisal methods among the respondents sampled in the quantitative phase of the study. Likewise, the EFA and CFA results did not identify these factors as significant. These findings may have resulted because some projects (public and government funded) are provided for the benefit of the community. However, these appraisal approaches are needed to evaluate projects and make decisions on more acceptable and beneficial investments for financial and economic status as was the case with the feasibility study of Metro Rail projects in Madurai in India (Subash *et al.*, 2013).

In summary, findings from the EFA and CFA supported that for a transportation feasibility study to be comprehensive, six critical factors must be considered and incorporated. These include investment appraisal methods, finance availability and source, user needs, local environment, available planning data and strategic support. The implications of these findings are that the sustainability of projects would depend on these critical factors identified. The success of a project is determined by the assumptions that are set during the feasibility study process (Subash *et al.* 2013). Therefore, a comprehensive feasibility study should incorporate these highlighted factors. Based on these findings, the hypothesised relationships were postulated for testing.

8.3 DIRECT INFLUENCE OF TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDY FACTORS ON THE QUALITY OF FEASIBILITY STUDIES

The general hypothesis was that transportation infrastructure feasibility study (TIFS) factors had a direct influence on the quality of feasibility studies (FQ), in terms of the processes employed and the people involved. Generally, the findings suggested that the quality of feasibility studies was likely to be influenced by the factors considered during the feasibility studies. Specifically, the results suggested that it was possible for feasibility studies to be modified as a result of the methods of appraisal used in the analysis of the investment potential or future performance of the project, finance availability and sources, available data and strategic support for the project.

The influence of appraisal methods was the strongest on the quality of feasibility studies, among the significant factors identified. The implications of this finding is that reliable decision-making can be made by relevant people with knowledge and expertise on feasibility studies and those who are directly or indirectly concerned based on a combination of appraisal methods (Tanczos and Kong, 2001). Different methods of evaluating investments at the conception stage demand that experts in various fields are involved. Experts in various fields are needed to conduct scoping and specialist studies using different methodologies to establish potential costs and benefits given different future scenarios (Hyari and Kandil, 2009). Critical to good quality decision-making is an ability to understand, incorporate and balance off the wider impacts and considerations on a project (Mackie and Nellthorp, 2018). The relationship between the methods employed during feasibility studies and the people involved was highlighted on the Gautrain project where environmental impact assessments, cost-benefits analysis, and multi-criteria evaluations were undertaken with various experts knowledgeable on the different aspects. The project also engaged stakeholders whose input were required in the development of scenarios for cost-benefit analysis and multi-criteria analysis.

The finding that consideration of sources of finance relates to the quality of the feasibility studies was supported in Linkama *et al.* (2018), which captured that sources of funds and subsequent allocation of funding to different aspects of a proposed transportation infrastructure projects was crucial in transport planning. This therefore involves decision making and procedures to cater for potential changes in funding and impact on set goals during the life cycle of the projects. Moreover, the complexity and huge costs involved in urban transportation infrastructure projects necessitate that sources of financing for capital, operations and maintenance are put in place at the conceptualisation stage of projects, with attention to who benefits and pays, and who would be affected in the long run (Ardila-Gomez and Ortegon-Sanchez, 2016). Agreements and contracts including financial risk containment measures need to be put in place, as was done on the Gautrain project in South Africa.

The finding that strategic support and the process employed in feasibility studies were related, corresponded with the views expressed by the World Bank (2008). Considerations of the leadership, strategic stakeholder support and commitment to a proposed project from start to finish is critical and this involves participation of a variety of people. Through stakeholder consultation, the roles and responsibilities of the stakeholders, including who is to benefit and pay, who is to provide the funds and the political will and commitment that will drive, champion and sustain the project are identified. This was clearly delineated on the Gautrain project in South Africa studied (section 5.4.1.2), where a performance contract was precisely put in place to stipulate what was required of the parties and the desired outcomes during the operational stage (Levitt and Eriksson, 2016). This was not the case on the BRTS in South Africa studied (section 5.4.1.6), where insufficient time was allowed for the process of stakeholder consultation and as a result, mini-bus and taxi operators were not fully committed to the integration of the rapid transit system. The BRT in South Africa was not well integrated with existing competing transport modes, even after strategies had been put in place as a precautionary measure (Venter, 2018). Bus and taxi drivers were employed to run the BRTs; however, competition and minimal co-operation with the taxi industry who share the same priority lanes, were still rife and this hampered cost-effectiveness of the BRT system.

The finding that user needs had no significant influence on the quality of feasibility studies was surprising. This finding was not in line with the views expressed in extant studies. Transport infrastructure initiatives need to be demand-driven and developed in a participatory manner (World Bank, 2008). Therefore, inclusion of the needs of the users including mobility, accessibility, comfort and reliability of a transportation mode is important at the critical stage of feasibility studies (Subash et al, 2013). These needs are identified in a public consultation process which contributes to the comprehensiveness of feasibility studies. Different actors and stakeholders involved in the delivery of transportation infrastructure need to be identified and their needs taken care of at the conceptual stage, to avoid uncertainties in the life cycle of projects (Froschauer, 2010).

Likewise, the finding that local environment was not significant on the processes and people involved in feasibility studies was also unexpected. This could be because the existing environment including features of the site, anticipated number of residents as well as contextual factors such as nature, type and setting of the proposed project, have to be considered in order to make decisions regarding the development. Understanding roadway and active facilities as well as land uses currently serving an area is critical in the development of feasibility studies in order to serve transport needs in terms of integration and spacing scenarios (Pojani and Stead, 2015). In addition, design and scope requirements for the existing projects are made based on the conditions obtainable at a particular time or period. Condition-based maintenance can be performed when certain indicators inferred from the asset present signs of an impending failure (Fourie and Zhuwaki, 2017:151). In addition, prevailing built and natural conditions, transport characteristics and land use conditions within the area were paramount considerations in determining processes and alternative frameworks for developing urbna transport in developing countries (Vasconcellos, 2014). Therefore, attention to the local environment is important as it helps to identify the needs and scope of works as well as processes to be followed to ensure that a good quality feasibility study is produced.

The findings in the current study were significant in the sense that with increased attention to the methods employed to evaluate proposed investments, the financial sources, data available and strategic support for the project, the involvement of a variety of people and adherence to procedures to ensure the production of good quality feasibility studies is likely.

8.4 DIRECT INFLUENCE OF FEASIBILITY STUDY QUALITY ON PROJECT SUSTAINABILITY

The general hypothesis that FQ had a direct influence on PS was statistically supported, albeit to the extent of the people involved. The results suggested that the people involved in feasibility studies had an influence on the sustainable performance of transportation infrastructure of projects. In a study by De Jong *et al.* (2013), it was captured that improving cost and benefit estimates, identifying risks and risk-containment measures, and clearly defining scope and objectives of the project entails involvement of expertise to adequately predict these uncertainties which could affect projects at the operational stage. In addition, identification of errors by those who understand and have knowledge of the feasibility study processes and intricacies contributes to better performance (Subash *et al.*, 2013). Therefore, these views align with the findings of the current study.

The findings with regard to the processes involved in feasibility studies were not expected. Although the findings were not statistically significant, the role of a clearly delineated feasibility study stage was highlighted on the studied cases, the BRT and Gautrain projects in South Africa. On one hand, the Gautrain project had two phases of feasibility studies which entailed clear processes to amass information regarding the project, discussions with the stakeholders and concessionaires, financial implications and close, and environmental impact assessments and management. In the two years it took to conduct the feasibility studies on the Gautrain project, risks to the project, measures to contain the risks and alternative solutions were evaluated and developed. On the other hand, the BRTs completed in three years, and there was insufficient time dedicated to the critical stage of feasibility studies (section 5.4.1.6). This had led to an unsustainable system that depends on subsidies. These views were supported in Polzin (2002) and Joewono and Kubota (2006), which captured the positive influence of a comprehensive feasibility on the performance of projects. The authors opined that system thinking should focus on processes to identify risks and mitigating actions or counter measures to achieve desired outcomes. Improving in transport safety entails adopting a streamlined approach to evaluation of alternatives with regard to priorities (risks and road users), high-risk areas, and roles and responsibilities for specific good practice interventions (institutional capacity), all of which are identified during feasibility studies (Bliss and Breen, 2013). In addition, if safety management processes are not put in place during feasibility studies, the result would be poor traffic safety during the operational stage (Shen *et al.*, 2011). Therefore, risks and uncertainties should be addressed at the planning stage of transportation infrastructure and services.

Further, the processes involved in feasibility studies, including involving all stakeholders, influence user acceptability. Therefore, the finding of the current study with regard to the influence of the processes involved on user acceptability was not in line with other studies which opined that public opposition is rife if stakeholders' input and needs are not taken into account during development of projects. In Zou *et al.* (2008), possible alterations and changes to existing roads were not addressed at the design and feasibility stage of the Sydney Cross City Tunnel PPP Project in Sydney Australia, and this led to public opposition and negative perception at the operational stage. In addition, the relationship between user safety perceptions as well as experiences and acceptability of a particular mode of transport was demonstrated (Joewono and Kubota, 2006).

In other studies, inadequate consultation processes with the stakeholders, inadequate planning, and inadequate financial management and costing evaluations led to public opposition on the e-toll project in Gauteng, South Africa, and the Nicaraguan canal in Nicaragua (Erlich, 2015; Matsiliza, 2016). The construction of the alleged world's largest infrastructure project, the Nicaraguan canal faced opposition as a result of environmental concerns (threat to livelihoods, displacements, and destruction of aquatic life) from the project (Erlich, 2015). Questions were raised as to the opportunity costs of the projects: should the projects rather be dropped or built, in what better ways can the infrastructure be provided to serve the populace with minimal negative impacts and increased acceptability? These questions needed to be addressed during the critical stage of feasibility studies in order to ensure sustainability.

Therefore, in general, involving the relevant people, including professionals with experience in the feasibility studies, team members including managerial support, and stakeholders, ensures improvement in the quality of feasibility studies as relevant risks are identified and measures are put in place to avert the risks (Hyari and Kandil, 2009). In other words, the higher the involvement of relevant people and procedural steps taken to ensure that a comprehensive feasibility study is produced, the more sustainable the projects would be. The general hypothesis that the quality of feasibility studies had a direct influence on the sustainable performance of projects was therefore supported.

8.5 DIRECT INFLUENCE OF TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDY FACTORS ON PROJECT SUSTAINABILITY

The general hypothesis was that TIFS factors had a direct influence on project sustainability indicators (infrastructure condition and impacts, user acceptability, financial sustainability as well as safety and security). The findings yielded support to reject the general null hypothesis that here was no influence.

The finding that strategic support had an influence on all the project sustainability factors corresponded with findings from extant studies, which emphasised the importance of strategic support in achieving project sustainability. The success of the Gujarat State Highway project in India rested on the continued strong leadership and commitment of top management and stakeholders (World Bank, 2010). In addition, leadership and commitment of management was found to influence maintenance costs and the quality (physical condition) of highway infrastructure projects in Egypt (El-Maaty *et al.*, 2016). Further, Froschauer (2010) and Barnes-Dabban *et al.* (2017) captured the essence of consideration of all stakeholders' interests and needs including arrangements and structures for management and operations, incentive frameworks, public consultation and buy-in. Ignaccolo *et al.* (2017) emphasised the need to incorporate stakeholders' priorities in complex transport decisions. These studies supported the finding that strategic support was indeed paramount in project sustainability.

Similarly, the consideration of user needs on financial sustainability was found to be statistically significant. This has to do with the demand for the infrastructure services and willingness of the end users to pay. These views were supported in Shen *et al.* (2011) who opined that the financial success of a project depends on the market, viz-a-viz the demand and supply. In their opinion, 'the implementation of infrastructure projects should account for the demand by the market, otherwise, the project would fail' (Shen *et al.,* 2011:447). User's interests have to be attended to since they have to pay the set toll fees (Suanmali *et al.* 2014). Additionally, the importance of involvement of experts with knowledge of feasibility study methods and processes was also reiterated (Hyari and Kandil, 2009; Subash *et al.,* 2013). Further, results captured by Suanmali *et al.* (2014) and the Economic Times (2016) indicated that comfort and convenience of travel experienced by users influence revenue obtainable due to sustained demand or ridership. Convenience to the public was emphasised in Valentin *et al.* (2012) where the situation of a proposed power plant was investigated as it was envisaged to influence user acceptability while in operation.

Finance availability and sources was found to significantly predict infrastructure conditions and impacts, user acceptability as well as safety and security, as was expected. These findings were indicative of the fact that the more the funding available, the more the continuity and security of funding for asset maintenance and safety management, which will in turn translate to user acceptability while the infrastructure is in use. Without due attention to the future management the infrastructure during the feasibility studies, the services and structures will deteriorate and poor road conditions lead to dissatisfaction and traffic accidents (Pinard *et al.*, 2016; World Bank, 2013a; 2013b).

However, the finding that the influence of financial availability and sources was not significant on financial sustainability was surprising. This was an interesting finding since the multi-case study investigation revealed that consideration of financial availability and source during feasibility studies influences projects' financial sustenance. This finding was dissimilar to views captured by the World Bank (2013b), that a comprehensive analysis of diverse financial sources (such as vehicle registration fees, and congestion charges, axle control fees, fuel surcharges), and realistic estimation of rehabilitation and maintenance costs allow for more reliable financing management during the operational phase. The sources of finance and measures to ensure financial self-sustenance of the system should be put in place at the conception of the project in order to endure that capital invested is recovered and there is still sufficient funding for maintenance and operational activities, and thus maintain the condition of the assets to continue commanding set fees (GMA, 2015). The revenue streams to maintain the asset while in operation have to be put in place at the feasibility study stage (World Bank, 2005:1). Considerations of financial input from investors and sources of financial sustenance of the system are related to capital recovery and revenue generation.

The hypothesised relationships with regard to local environment did not yield statistically significant results. This finding was inconsistent with results in extant literature which concurred that prevailing local conditions influence the outcome of planned rehabilitation projects (ADB, 2013a; GPDRT, 2015). Soehodho (2017) indicated that inadequate consideration of the prevailing local conditions in terms of physical condition (deterioration) and traffic growth had resulted in poor management of safety in Indonesia. Further, the quality of infrastructure contributes to passenger satisfaction and positive impacts (with regard to accessibility) (Subash *et al.*, 2013; Kurt, 2018).

The above results suggested that more attention to strategic support for the project, finance, and data used during feasibility studies would result in better performance at the operational stage of projects. Therefore, holistic consideration of a wide range of sustainability-focused factors allows for planning and decision-making regarding social, economic, environmental, institutional and physical infrastructure aspects of the project (Rawal and Devados, 2012; Shen *et al.*, 2013). There are many factors which influence the project, namely: what the public thinks, what the economic appraisal informs and the political environment or strategic support, and these should be incorporated in the decision-making during feasibility studies (Mackie and Nellthorp, 2018). Specifically, more attention to the methods of appraisal used, financial availability and sources, user needs, local environment and conditions, available data and strategic support for the project is necessary in order to assure transportation stakeholders of the worthwhileness of the project and future sustainability.

8.6 INDIRECT INFLUENCE OF TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDY FACTORS ON PROJECT SUSTAINABILITY

The general hypothesis that TIFS factors indirectly influence the sustainability of projects, mediated by the quality of feasibility studies was found to be significant. This finding was not surprising because the mediatory role played by the people involved and the processes followed to ensure that a comprehensive feasibility study is produced was apparent. Comprehensive and valid feasibility studies are produced when experts are involved and procedures are followed, and this in turn influences the extent of risk assessments and decision making based on reliable information (Hyari and Kandil, 2009; Subash *et al.*, 2013). In turn, projects built based on misleading information from feasibility studies result in cost overruns, benefit shortfalls, stakeholder dissatisfaction, low demand, unfavourable institutional environment, poor quality infrastructure, and poor safety performance (Abou-Zeid *et al.*, 2007; Flyvberg *et al.*, 2009; 2014; Stefánsdóttir, 2015).

Further, it had been emphasised that careful selection of methods of appraisal as well as auditing and review of feasibility study outcomes contribute to ensuring that a comprehensive feasibility study is produced (Hyari and Kandil, 2009). In addition, the combination of the different methods of appraisal requires expertise on the subject in order to identify risks and uncertainties, consider future conditions and potential effects of alternative strategies on all the project sustainability aspects (including infrastructure conditions (maintenance), financial management and user acceptability (Subash *et al.*, 2013; Bracarense *et al.*, 2016). Better project risk and impact assessment as well as decision-making ultimately result in desirable impacts and sustainable performance of infrastructure during the operational stage of projects.

The effectiveness of an agenda to improve the sustainability of projects ties with the processes followed to ensure that all potential risks and uncertainties to the projects are planned for, including for financial, physical, institutional and social sustainability (Joewono and Kubota, 2006). The financial model, which is specified during the feasibility study of projects to ensure that there are no misunderstandings or complaints from investors about revenue, influences financial management during operations (ADB, 2005). This was the case on the studied Gautrain project, whereby most risks were contained in the setting of a flexible patronage guarantee to accommodate risks in the operation and maintenance stage (GMA, 2015). The patronage guarantee was put in place to cater for uncertainties with regard to passenger volumes and revenue risks (shortfalls) (Venter, 2013). Therefore, project risks including unforeseen demand and revenue shortfalls were catered for. This meant that future generations would not be burdened by financial liability of the system (Musonda *et al.*, 2019). Decisions regarding procurement and finance must be taken early in the project and the right concession form needs to be selected clearly by the right people and through the right processes in order to ensure sustainable projects (Allport *et al.*, 2008:47). Furthermore, contract management mechanisms and water-tight agreements stating the obligations of the private investor or concessionaire, put in place at the conceptual phase contributes to effective financial management during operations (GMA, 2015).

The finding that TIFS had an indirect influence on project sustainability was also supported in Muskin (2017), who indicated that endorsement and adoption of a project and involvement of stakeholders should go hand in hand with expertise involved during feasibility and conception as well as responsibility in order to ensure that projects are sustainable. Specialised aspects and technology still require professionals with relevant experience. It is therefore arguable that people and procedures were important in developing plans to ensure that a project performs as expected during the operational stage (Soliño and De Santos, 2010). Moreover, a lack of experience concerning procedures or methodology for evaluating different aspects of a project pose major problems at a later stage in the life cycle of a project (Che et al, 2002). Feasibility studies should follow a process of identification of alternatives, collecting relevant information about the alternatives, evaluating them holistically and making conclusions about the worthwhileness of the investments based on subjective and objective bases (Wey and Wu, 2007; Mackenzie and Cusworth, 2007; Hyari and Kandil, 2009). If a phase in the feasibility procedure is skipped or not properly undertaken, chances are that value may be destroyed since some of the questions will be left unanswered and bias may be introduced (Mackenzie and Cusworth, 2007; Salling, 2013; De Reyck *et al.*, 2015; Flyvberg, 2016).

Moreover, objective methods of appraisal need expert opinion in a way. To perform complex and sometimes prolonged analyses of project alternatives require expertise that may even be scarce within an entity and/or costly to outsource. The quality of the decision-making process, with the people involved and procedures involved, is a key factor in the successful planning for transportation infrastructure (Cascetta *et al.*, 2015).

In summary, the general null hypothesis that the indirect influence of TIFS on PS, mediated by people and processes, held true. The overall results in the current study therefore, suggested that in order to undertake a comprehensive and reliable feasibility study, methods of appraisal, availability and sources of finance, user needs, local environment, available data and strategic support for the project while in operation should be considered. Then, based on the consideration of these factors, decision-making can be made in order to plan and develop sustainable transportation infrastructure projects.

8.7 CHAPTER SUMMARY

The current chapter presented a discourse on the findings from the quantitative survey. The findings revealed that a comprehensive feasibility study could be defined by a six-factor structure as evinced by the fit measurement model. The findings supported that feasibility studies influence the quality of feasibility studies. In addition, the quality of feasibility studies significantly predicted project sustainability. Similarly, the TIFS factors were found to be influential on project sustainability. In addition, extant literature supported the findings of the present study.

The conclusions drawn from the above findings were presented in the next chapter. Additionally, recommendations were made based on these findings and conclusion.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

9.1 INTRODUCTION

The overall purpose of the study was to establish a comprehensive feasibility study model that can be utilised for transportation projects. This chapter presented a discourse on how the objectives of the study were accomplished. The study sought to establish: how feasibility studies were conducted on transportation infrastructure projects; factors considered in transport infrastructure feasibility studies (TIFS) of the projects; the influence of the identified TIFS factors on the quality of feasibility studies; the influence of feasibility study quality on the sustainable performance of projects; influence of the TIFS factors on project sustainable performance and to develop a validated model of feasibility study factors for transportation project sustainability.

In addition, the current chapter presented conclusions drawn from the mixed-method sequential exploratory study. The conclusions were related to the objectives as they were accomplished during the qualitative phase using document analysis and interviews, and the subsequent quantitative phase using questionnaires.

To achieve the objectives of the study, an initial review of literature provided the background to the study and an understanding of the phenomenon of the impact of feasibility studies on project performance, as well as gaps to be investigated. Thereafter, conducting a qualitative study in the first phase using structured interviews with feasibility study consultants and document analysis of actual feasibility study reports, major themes emerged on how feasibility studies for the projects were conducted. These included attention to who was involved in conducting the studies viz-a-viz expertise, vetting and auditing of the feasibility study outcomes, and oversight; the factors considered, as well as the data and methods employed in conducting the feasibility studies. These themes were evident during the analysis of information from the projects (cases) studied. In addition, during the qualitative phase, the performance of the projects was espoused from interviews and progress reports availed by the project managers.

The second quantitative phase, using questionnaires distributed to participants who were experts and willing to participate, amassed relevant data, which were thereafter statistically evaluated to test the theory (from the qualitative phase and extant literature) that feasibility study elements influence the quality of feasibility studies and in turn project performance. Therefore, multiple methods were necessary in order to achieve the objectives of the study.

In addition to the summary of the research in terms of how the objectives were achieved, this chapter presented the contribution of the study and recommendations for policy, practice and future research were presented, in line with the conclusions drawn from the study.

9.2 ACHIEVEMENT OF OBJECTIVES

9.2.1 Objective 1

The first objective was to establish the critical factors that should be considered in transportation infrastructure feasibility studies. This objective was accomplished using document analysis and interviews, as well as a questionnaire survey. Transportation projects which had been in operation for at least two years were included in a multi-case qualitative study investigation, prior to the quantitative phase.

Feasibility study and transportation study reports on the projects were analysed and professionals who were involved with the projects at different stages were interviewed. Findings from the eight case study projects on how feasibility studies are conducted revealed important aspects including the expertise involved, factors on which assessments, decision-making and project selection were based, methodological considerations, processes involved, and data used (Tables 5.2 and 5.3).

Findings revealed that feasibility studies were conducted by local and international consultants and were also reviewed by experts, who had experience and knowledge about feasibility studies (Table 5.3). The processes and methods entailed financial, site and environmental surveys, demand, technical and socio-economic studies conducted based on the desired outcome during the operational stage. It was important to include output specifications in order to ensure that critical measures were put in place at the onset, to take care of exigencies and uncertainties that may occur in the life cycle of the project, as seen on the Gautrain project (section 5.4.1.2). What was envisaged to take place in future, that is, the operational intent, was considered in the feasibility studies undertaken for the projects. This suggested a relationship between feasibility studies and project performance in terms of sustainability. In addition, the importance of assessing alternatives with regard to route options and mitigation strategies for uncertainties was stressed. Further, participation of stakeholders and the general public, who use the facilities and services in the decision making process, was also found to be critical since their acceptability is an important element of sustainability (section 7.4.3.2).

The criteria factors incorporated into feasibility assessments included design, future returns on the projects (in the case of PPPs – the Gautrain and BRTs), life cycle costs and affordability, institutional frameworks in place to champion and manage the projects, safety and security, as well as existing environmental conditions and land uses.

Additionally, the data used in feasibility studies of the sampled projects included traffic counts, archive information (design, structural and maintenance) on existing and similar projects, infrastructure master plans, international projects as examples, policy documents and environmental impact assessments (Table 5.3).

Further findings espoused that performance of the projects was assessed based on socio-economic benefits and returns, condition of physical infrastructure, safety and security, accessibility and mobility, stakeholder satisfaction, environmental compliance and preservation, ridership, service quality, and affordability. The projects were reported to be performing as well as expected, with the exception of the BRTs, which was not doing well on the expected returns, and this was primarily because insufficient resources including time, expertise and effort, were not committed to conducting a comprehensive feasibility study (section 5.5.2). As a result, the plethora of factors which should have been considered to ensure that the project performed optimally with regard to financial, and socio-economic benefits, were not taken into consideration.

An exploratory factor analysis (EFA) of the TIFS elements indicated that feasibility studies can be adequately explained by a six-factor solution (Table 7.2), as opposed to the three-factor structure initially theorised (Figure 6.2 and Table 6.1). The six common factors, which emerged with twenty-three strongly loading items, included methods of appraisal, finance availability and sources, user needs, local environment, available data and strategic support (Table 7.8). These factors were observed to explain the highest percentage of variance among the factors considered.

The factors were validated using confirmatory factor analysis. The six-factor model of feasibility study elements (latent constructs) was found to be valid and reliable for further analysis, with eighteen observed variables (Figure 7.2). Construct, convergent and discriminant validity were established for the six-factor measurement model from CFA. In addition, reliability of the model was established using composite reliability and average variance extracted tests (Tables 7.20 and 7.21).

9.2.2 Objective 2

The second objective was to establish the influence of transportation infrastructure feasibility study (TIFS) factors on the quality of feasibility studies (defined as the people and processes involved) and in turn, sustainable performance of transportation projects. This objective was accomplished through a questionnaire survey.

The quality of feasibility studies was initially theorised to be measured by a two-factor structure consisting of ten items made up of people and processes (Table 6.2). The EFA also revealed a two-factor structure consisting of seven items for *procedures* and *people* (Table 7.10). Further, the two-factor structure was validated in the CFA, albeit with six measures (Figure 7.4). These indicated that a comprehensive feasibility study should entail procedural steps or phases and involvement of the right people in identification of risks as well as mitigation or containment measures. The influence of the TIFS factors on the quality of feasibility studies was thereafter tested using SEM.

Findings from the SEM indicated that methods of appraisal, finance availability and sources, available data used as well as strategic support for the project were influential on the quality of feasibility studies in terms of the entailing procedures and people involved in the process (Table 7.38).

9.2.3 Objective 3

The third objective of the study was to establish the direct influence of feasibility study quality (FQ) on project sustainability (PS). This objective was achieved through the questionnaire survey. Project sustainability was initially theorised to be measured by a six-factor structure comprising socio-economic factors, financial factors, condition of physical infrastructure, safety and security, stakeholder satisfaction and service quality, with twenty-eight items (Figure 6.3 and Table 6.3). However, the EFA indicated a four-factor solution including infrastructure condition and impacts, user acceptability, financial sustainability as well as safety and security, with fourteen items (Table 7.14). The measurement model with eleven variables from the CFA (Figure 7.6) was validated prior to structural modeling of the influence of feasibility study quality on project sustainability.

Findings from the SEM analysis revealed that FQ had a direct influence on PS, especially to the extent of involving the right people and structures in undertaking feasibility studies. The findings suggested that improving the quality of feasibility studies entailed attention to the inclusion of professionals and stakeholders whose input are critical in ensuring that the projects are sustainable in the long run. The right people here included experts and stakeholders whose decisions and interests affect, or might be affected by the project in question.

The findings suggested that there was a relationship between the quality of feasibility studies and the outcome of projects at the operational stage (Table 7.41). Failure to progress through the essential processes, with the relevant structures to make decisions, and the consideration of data available, while incorporating a wide array of criteria factors, potentially lead to misinformation and misleading evaluations on which important decisions to build are made, which in turn leads to poor project performance at a later stage.

9.2.4 Objective 4

The fourth objective was to establish the relationship between TIFS and PS, which was theorised to be both direct and indirect relationships. This was achieved through the questionnaire survey. Therefore, this objective had a two-fold evaluation, direct and indirect effects.

Findings on the direct influence of TIFS on PS revealed that the methods of appraisal, as well as consideration of finance availability and sources, user needs and strategic support, had a direct influence on project sustainability (Table 7.44). Hence, the general theory that a direct relationship existed was supported.

The results of the indirect effect investigation also evinced that there was a significant relationship between TIFS and PS, indicating that the mediating role of the quality of feasibility studies (defined by the people and processes) was significant (Table 7.46). Therefore, the theory was supported.

The direct and indirect relationships were also positive, and thus indicating that overall, if the identified TIFS factors are considered during project feasibility studies, with the right structures, procedures and people in place, the sustainability of transportation projects is possible.

9.2.5 Objective 5

The fifth objective was to establish a validated conceptual TIFS model for transportation infrastructure project sustainability. This objective was achieved through the questionnaire survey and inferential statistics including EFA, SEM (measurement model evaluation). The EFA established the minimum number of variables that defined or explained the most variance in the latent constructs. It was found that the hypothesised three-factor TIFS model did not hold true, as a six-factor solution emerged from the EFA (Table 7.8). The six-factor structure was found to be valid by the items loading strongly on each common factor. The internal consistency reliability of the constructs before and after the EFA was good, as evinced by the Cronbach alpha tests (Table 4.20). The constructs also achieved discriminant validity by loading strongly on a construct. Therefore, the null hypothesis that the TIFS model is not a three-factor structure could not be rejected.

The relationship between the variables and their related latent constructs were tested and validated in the CFA (section 7.5.2). The input sub-models in the CFA confirmed discriminant validity by the inter-item correlation coefficients less than 0.80. The outputs from the CFA were measurement sub-models whose fit were tested and found to be acceptable. The data reliability as well as construct, convergent and divergent validity were attained as captured by the composite reliability and average variance extracted tests.

The full latent structural model demonstrated a good fit to the sample data (Table 7.35). The postulated hypotheses were thereafter tested and the significant relationships were espoused (section 7.5.3).

Based on the above discourse, all the objectives of the study were met. The findings were envisaged to be beneficial to planners, policy makers, investors, owners and indeed all stakeholders in transportation infrastructure sector in devising strategies to ensure that decision making regarding project selection is based on a comprehensive and holistic feasibility study, which will go a long way in ensuring that sustainable projects are ubiquitous as opposed to the status quo at present.

9.3 CONTRIBUTION OF THE STUDY

The current research aimed to identify factors that should be considered in a comprehensive transportation infrastructure feasibility study (TIFS), which influence the quality of feasibility studies (FQ), measured by the processes followed and the people involved, and in turn, the transportation project sustainability (PS). Based on an extensive distillation of literature and a qualitative multi-case study, a conceptual framework was developed and subsequently tested and validated using quantitative analysis. This study contributes to research and practice in the following ways.

9.3.1 Contribution to knowledge

Findings from a detailed theoretical foundational review and a multi-case study, which espoused that inclusion of a wider variety of factors in feasibility studies influences the quality of the feasibility studies, and invariably, the performance during the operation stage, a framework was conceptualised around these relationships. The theorised relationships were tested in a subsequent quantitative phase to identify validated input parameters that contribute to good quality feasibility studies in order to ensure that the highly subjective process incorporates critical and often times uncertain variables, and the right people, in order to ensure a comprehensive and reliable appraisal and judgement.

By analysing the impact of a comprehensive feasibility study on transportation project sustainability, the study has shown how the factors considered in a feasibility study can directly and indirectly shape the performance of transportation infrastructure during the operation stage. These findings therefore contribute to the existing body of knowledge by identifying validated input parameters that contribute to good quality feasibility studies in order to ensure that the highly subjective process incorporates critical and often times uncertain variables, and the right people, in order to ensure a comprehensive and reliable appraisal and judgement.

Further, since the extent to which transportation infrastructure feasibility study factors, mediated by the quality of feasibility studies, had not been investigated previously, this study provides empirical and conceptual contribution in this regard. The current study lends support to previous studies on the subject of transportation project sustainability, but with particular contribution on the role of a comprehensive feasibility study stage as well as the mediatory role of the processes and people involved in the feasibility studies.

9.3.2 Methodological contribution

The research adopted a robust mixed-method sequential exploratory design (Table 4.1), to identify the impact significance of feasibility studies on project sustainability. A detailed literature review was initially undertaken to identify the existing theories regarding factors considered in transportation infrastructure feasibility studies, attributes of a good quality feasibility study, as well as project sustainability measures. A multi-case study was thereafter conducted to refine the theories developed from the literature review regarding the factors considered in feasibility studies, and the important role of feasibility studies in the sustainable performance of transportation projects during the operational stage. Statistical techniques including exploratory factor analysis, confirmatory factor analysis and structural equation modeling (with bootstrapping applications), validated the theoretical evidence amassed from literature review and multi-case studies, and rich insights and inference were made. Using these robust research techniques, the study was able to establish the factors which significantly influence the quality of feasibility studies and which in turn influence project sustainability. Thus, the study made methodological contributions to the body of knowledge regarding feasibility studies and project sustainable performance. These robust mixed method techniques allowed for an advanced conceptualisation and validation process to test the theory postulated in the current study, as opposed to the use of linear or multiple regression analysis or partial least squares techniques. Therefore, these research procedure and techniques are recommended in similar theory testing and validation studies of alternative models.

9.3.3 Contribution to policy and implications for practice

The current research drew out a number of positions and arguments about the criticality of adequate and comprehensive feasibility studies in ensuring that transportation infrastructure projects are sustainable in the long run. The significant feasibility study elements should serve as a minimum number of factors to be targeted at when planning for transportation infrastructure projects, with a view to ensuring sustainability. By identifying critical feasibility study factors and their impact on project sustainability, the study provided invaluable evidence to inform decision-makers and assist in the selection of feasible projects based on comprehensive feasibility studies, which are good, credible and reliable.

In summary, it is anticipated that findings from this study will result in developing more comprehensive feasibility studies which would in turn result in improved performance of transportation infrastructure projects. If the identified critical TIFS factors are taken cognizance of during feasibility studies, sustainability of transportation infrastructure projects would surely be possible.

9.4 LIMITATIONS AND RECOMMENDATIONS

The study was conducted in the nine provinces of South Africa and thus the results could be generalisable to other parts of South Africa that were not reached for the study. Similar studies could be undertaken with a wider geographical coverage to see if the results are tenable elsewhere, especially where priorities and views may differ on project selection and sustainability criteria, fiscal constraints, topographical and climatic characteristics. Therefore, future studies could use a different sample to decipher if the results would differ.

The study used a sample of 132 respondents and an even smaller number (125 cases, after deletion of outliers) for the structural modeling. Future studies could employ a larger sample to evaluate these relationships and validate or refute the findings of the current study. In addition, a different and/or unique sample, for instance, feasibility study consultants only, could be used. This might reduce the number of outliers and may result in a different outcome.

Additionally, based on the general idea that irrespective of the project, feasibility studies should consider all the possible influences and conditions that may affect the project during the operational stage, whether they are affected by or affecting the project in any way, the influence of project characteristics as a major factor was not considered. Future studies could elaborate on this upshot. Studies are recommended to determine the impact significance of the type of project and other attributes (size, number of private investors, clients) on the outcome of feasibility studies and project performance.

In the vein of TIFS factors which may be affected by projects (vice versa), further investigation of alternative non-recursive models could be embarked on in future studies, as this was not covered in the current study. The use of a non-recursive or formative model is recommended, whereby a reverse relationship between project sustainability measures and planning of projects may be investigated, especially on existing infrastructure projects. The research techniques used in the current study are recommended.

Further, relationships between and among the identified TIFS factors, as well as among the PS measures themselves, may be investigated further to determine related items which may be simultaneously attended to during feasibility assessments in order to improve effectuality and sustainability of transportation infrastructure projects. Furthermore, a validation of the current model using a case study or two is recommended to validate or refute the findings.

Moreover, since the main aim of the current research was to establish the role of a comprehensive feasibility study on the performance of projects while in operation, the full latent model, which was validated through the CFA, was used to test the direct and indirect influence of a comprehensive feasibility study on project sustainability. The factor loadings also showed the relationships between the constructs, which was the objective of the SEM. However, the relative importance of the constructs and individual variables was not expanded on. Further studies would therefore benefit from establishing the relative importance of the individual variables identified as critical factors in a comprehensive feasibility study.

9.5 SUMMARY AND OVERALL CONCLUSION

A transportation infrastructure sustainability model was developed with feasibility studies as the focus. It was theorised that the quality of feasibility studies, measured in terms of people and processes involved, was influenced by factors including the methods used to evaluate the projects, and consideration of finance availability and sources, user needs, available planning data and strategic support, and these in turn influenced the sustainability of projects.

Through a detailed literature review and qualitative enquiry (using document analysis and interviews analysed with the aid of the ATLAS-ti version 7 software), three theorised sub-models, including TIFS, FQ and PS, were refined and subsequently tested and validated through a questionnaire survey. The theorised factors were run through an exploratory factor analysis in the SPSS version 25 software to output common factor structures, which were found to be reliable based on Cronbach's alpha test for internal consistency reliability. Discriminant validity was also achieved at this stage, with items loading strongly on each of the common factors. The two-factor structure of FQ, six-factor structure of TIFS and four-factor structure of PS sub-models were thereafter run through confirmatory factor analysis to determine the best combination of variables related to the respective latent constructs. The emerged measurement sub-models achieved construct, convergent and discriminant validity. In addition, reliability of the sub-models was achieved as evinced by the composite reliability and average variance extracted tests. The fit statistics for each sub-model also had acceptable fit. Further, the full latent structural model, containing all the conceptualised relationships demonstrated an adequate match to the sample data.

An evaluation of the hypothesised relationships in the structural model indicated that the TIFS factors influence the people and processes involved during feasibility studies. The people involved in feasibility studies were also found to influence the sustainability of projects, and the TIFS factors predicted project sustainability, directly and indirectly. It was arguable that transportation infrastructure project sustainability can be achieved by attention to the methodological considerations incorporated during feasibility studies, financial resources, user needs, as well as strategic support for the project from start to finish and during operations, all of which influence the project while in operation. This would enhance the outcome of feasibility studies, which in turn influences the performance of the project at a later stage in its life cycle.

The findings of this study provide theoretical value since the extent to which transportation infrastructure feasibility study (TIFS) factors influence the sustainability of projects, identified from a detailed theoretical foundational review and multi-case study inquiry, had not been investigated previously. Moreover, the role of the people and procedures involved as mediating factors, had not been explored.

With the identification of the impact significance of the comprehensiveness and quality of feasibility studies on project sustainability using robust statistical techniques, structural equation modeling to validate rich theoretical evidence from an extensive literature review and multi-case studies of transportation infrastructure projects, rich contribution to research was made. Using robust research techniques, the study was able to establish the factors which significantly influence the quality of feasibility studies and which in turn influence project sustainability. Thus, the study made methodological contributions to the body of knowledge regarding feasibility studies and project sustainable performance.

The problem of unsustainability of projects can be diminished or indeed extirpated. However, it requires stakeholder support, time, expertise, methodological considerations, and cognizance of local environment and user needs as well as effort to be committed to a comprehensive and designated feasibility study stage in order to produce good quality feasibility studies. Good quality feasibility studies require an all-inclusive identification of potential risks and uncertainties that may crop up in the life cycle of a project, development of precautions and mitigation measures to cater for the exigent risks when they arise, as well as development of alternative solutions that could be assumed and implemented given the magnitude of probable risks identified. Development of comprehensive feasibility study requires the right people and processes to achieve reliable outcomes.

Enhanced quality of feasibility studies would ensure preparedness for future conditions and impacts and assure transportation infrastructure stakeholders of sustainable performance of the project in the long run, viz-a-viz, infrastructure condition and desirable impacts, user acceptability, financial management and safety and security. It therefore behoves transportation infrastructure stakeholders, planners and investors to commit more resources including time, expertise and effort to the feasibility stage with distinctive cognizance to the methods of appraisal used, stakeholders' interests and needs, financial resources, involving professionals with relevant experience on feasibility studies as well as the nature of the data, which directly affect the projects during the operational stage.

By identifying critical feasibility study factors and their impact on project sustainability, the study provided invaluable evidence to inform decision-makers and assist in the selection of feasible projects based on comprehensive feasibility studies, which are good, credible and reliable. Therefore, the study made vital contribution to practice. In sum, if the identified critical factors are taken cognizance of during feasibility studies, sustainability of transportation infrastructure projects would surely be possible.

REFERENCES

Abedi, G. Rostami, F. and Nadi, A. (2015). Analysing the dimensions of the quality of life in hepatitis B Patient using confirmatory factor analysis. Global Journal of Health Science, 7(7): 22-31

Abelson, P. (2003). Financing transport infrastructure: Public finance issues. Applied Economics. Sydney. http://www.appliedeconomics.com.au/pubs/papers/pa03_trans.htm Accessed 26 December 2018

Abou-Zeid, A., Bushraa, A. and Ezzat, M. (2007). Overview of feasibility study procedures for public construction projects in Arab countries. JKAU: Eng. Sci., 18(1): 19–34.

Adams, A. and Cox, A. L., (2008). Questionnaires, in-depth interviews and focus groups. In Research Methods for Human Computer Interaction, pp. 17-34. Cairns, Paul and cox, Anna L. (eds). Cambridge University Press, United Kingdom.

African Development Bank (AfDB) (2009). Dakar-Diamniadio Highway Project. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Senegal_-_Dakar-Diamniadio_Highway_Project_-_Appraisal_Report.pdf Accessed 17 June, 2018.

Agbo, A., Li, W, Atombo, C. and Lodewijks, G. Feasibility study for the introduction of synchromodal freight transportation concept (2017). Cogent Engineering, 4(1). Doi: 10.1080/23311916.2017.1305649

Aguinis, H., Gottfredson, R. K. and Joo, H. (2013). Best-Practice Recommendations for Defining, Identifying, and Handling Outliers. Organisational Research Methods, 16(2): 270-301.

Ahmad, S., Zulkurnain, N. N. A., and Khairushalimi, F. I. (2016). Assessing the validity and reliability of a measurement model in structural equation modelling (SEM). British Journal of Mathematics and Computer Science, 15(3): 1-8

Ahmed, J. U. (2010). Documentary Research Method: New Dimensions. Indus Journal of Management and Social Sciences, 4(1):1-14.

Ahn, Y. H. and Kim, K. (2014). Sustainability in modular design and construction: a case study of ‘The Stack’. International Journal of Sustainable Building Technology and Urban Development, 5(4): 250–259

Akadiri, P. O., Chinyio, E. A. and Olomolaiye, P. O. (2012). Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector. Buildings, 2: 126-152

Alasad, R., Motawa, I. and Ogunlana, S. (2012). A system dynamics-based model for demand forecasting in infrastructure projects: A case of PPP projects. The 28th Annual ARCOM Conference, 3-5 September, Edinburgh, United Kingdom. pp. 327-336

Alasad, R., Motawa, I. and Ogunlana, S. (2013). A system dynamics-based model for demand forecasting in PPP infrastructure projects: A case of toll roads. Organisation, Technology and Management in Construction, 6(2): 791-798

Allen, H. (2013). Africa's First Full Rapid Bus System: The Rea Vaya Bus system in Johannesburg, Republic of South Africa. Case study prepared for Global Report on Human Settlements. United Nations. Available from http://www.unhabitat.org/grhs/2013. Accessed 31 July 2018

Allison, P. D. (2003). Missing Data Techniques for Structural Equation Modeling. Journal of Abnormal Psychology, 112 (4): 545–557

Allport, R., Brown, R., Glaister, S. and Travers, T. (2008). Success and failure in urban transport infrastructure projects. https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-transport-studies/Success-and-Failure-in-Urban-Transport-Infrastructure-Projects.pdf Accessed 24 June 2018

Al-Masaeid, H. R. and Al-Omoush, N. J. (2014). Traffic volume forecasting in rural roads in Jordan. Jordan Journal of Civil Engineering, 8(3): 319-331

Alshenqeeti, H. (2014). Interviewing as a data collection method: A critical review. English Linguistics Research, 3(1): 39-45.

Altman, D. G. and Bland, J. M. (2005). Standard deviations and standard errors. BMJ. 2005 Oct 15; 331(7521): 903.

Alvi, M. H. (2016). A manual for selecting sampling techniques in research. Munich Personal RePEc Archive (MPRA) Paper No. 702218. https://mpra.ub.uni-muenchen.de/70218/ Accessed 13 October, 2018.

Andrew and Thoms, I. M. (2012). Design and construction of the Gautrain rapid rail link. Management, Procurement and Law, 165(1):41-54

Anney, V. N. (2014). Ensuring the quality of the findings of qualitative research: Looking at trustworthiness criteria. Journal of Emerging Trends in Educational Research and Policy Studies, 5(2): 272-281

Ansar, A., Flyvbjerg, B., Budzier, A. and Lunn, D. (2016). Does infrastructure investment lead to economic growth or economic fragility? Evidence from China. Oxford Review of Economic Policy, 32(3): 360-390

Arcus-Gibb (2010). City Deep/Kazerne freight hub transportation study. March 2010.

Ardila-Gomez, A. and Ortegon-Sanchez, A. (2016). Sustainable urban transport financing from the sidewalk to the subway. World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/23521/9781464807565.pdf?sequence=1 Accessed 15 Jan 2019

Asian Development Bank (ADB) (2013a). Draft feasibility study report: Manatuto to Natarbora road. Timor Leste Road Network Upgrading Project feasibility report. https://ww.adb.org>linked-documents. Accessed 18 November 2018

Asian Development Bank (ADB) (2013b). Issues in road maintenance. Annual Evaluation Review https://www.adb.org>linked-documents. Accessed 8 September 2016

Australian Government (2016). The Australian government’s response to infrastructure Australia’s Australian Infrastructure Plan. Commonwealth of Australia. https://transportinfrastructurecouncil.gov.au. Accessed 05 June 2017.

Awang, Z. (2012). Validating the measurement model: CFA. Ch. 3 in A Handbook for SEM. https://www.researchgate.net>download. Accessed 9 December 2018

Ayres, L., Kavanaugh, K. and Knafl, K. A. (2003). Within-case and across-case approaches to qualitative data analysis, Qualitative Health Research, 13(6): 871-873.

Babu, G. L. S., Reddy, K. R., De. A. and Datta, M. (2017). Geoenvironmental practices and sustainability. Springer.

Bandara, W., Furtmueller, E., Gorbacheva, E., Miskon, S. and Beekhuyzen, J. (2015). Achieving rigour in literature reviews: Insights from qualitative data analysis and tool-support. Communications of the Association for Information Systems, 37(1):154-204.

Barde, M. P. and Barde, P. J. (2012). What to use to express the variability of data: Standard deviation or standard error of mean? Perspect Clin Res., 3(3): 113–116.

Barfod, M. B. and Leleur, S. (eds.) (2014). Multi-criteria decision analysis for use in transport decision making. DTU Lyngby: Technical University of Denmark, Transport. http://orbit.dtu.dk/files/104276012/DTU_Transport_Compendium_Part_2_MCDA_.pdf Accessed 7 January 2018

Barnes-Dabban, H., van Tatenhove, J. P. M., van Koppen, K. C. S. A. and Termeer, K. J. A. M. (2017). Institutionalizing environmental reform with sense-making: West and Central Africa ports and the 'green port' phenomenon. Marine Policy, 86:111-120 ·

Beckers, F. and Stegemann, U. (2013). A risk-management approach to a successful infrastructure project. McKinsey and Company. https: www.mckinsey.com/industries/cpitl-projects-and-infrastructure/ouinsights/a-risk-management-approach-to-a-sucessful-infrastructure-project. Accessed 8 January 2017

Bentler, P. M. and Chou, C. (1987). Practical issues in structural equation modelling. Sociological Methods and Research, 16(1). 10.1177/0049124187016001004.

Berg, S. V. (2009). Investing in infrastructure: Factors affecting sector performance. Claves de la Economia Mundial. pp. 1 - 11

Beria, P. (2007). Transport megaprojects in Italy. A comparative analysis of economic feasibility studies into EIAs. European Transport, 36 (2007): 27-46

Beria, P., Bertolic, A. and Grimaldi, R. (2018). Integration between transport models and cost-benefit analysis to support decision-making practices: Two applications in Northern Italy. Advances in Operations Research, Article ID 2806062

Bhattacharya, A., Oppenheim, J. and Stern, N. (2016). Driving sustainable development through better infrastructure: Key elements of a transformation program. Global Economy and Development. https://www.brookings.edu/wp-content/uploads/2016/07/07-sustainable-development-infrastructure-v2.pdf Accessed 19 June, 2017

Blair, E. (2015). A reflexive exploration of two qualitative data coding techniques. Journal of Methods and Measurement in the Social Sciences, 6(1): 14-29

Blanco, H. and Moudon, A. V. (2017). Havana's transportation system: Future scenarios. Transportation Research Procedia, 25: 4683-4695

Bliss, T. and Breen, J. (2013). Road Safety Management Capacity Reviews and Safe System Projects.

http://documents.worldbank.org/curated/en/400301468337261166/pdf/842030WP0ENGLI0Box0382132B00PUBLIC0.pdf Accessed 31 December 2017

Boddy, C. R. (2016). Sample size for qualitative research. Qualitative Market Research 19(4):426-432

Bollen, K. A. and Noble, M. D. (2011). Structural equation models and the quantification of behaviour. Proceedings of the National Academy of Sciences, 108(3): 15639–15646

Bon, B. (2015). A new megaproject model and new funding model. Travelling concepts and local adaptations around the Delhi Metro. Habitat International, 45: 223-230

Bongardt, D., Schmid, D., Huizenga, C. and Litman, T. (2011). Sustainable transport evaluation: Developing practical tools for evaluation in the context of the CSD process. Department of Economic and Social Affairs. United Nations, Background Paper No. 10. Eschborn, Germany. www.un.org>dsd>res_pdfs>csd-19 Accessed 24 September, 2016

Boomsma, A. (2000). Reporting analyses of covariance structures. Structural Equation Modelling, 7(3): 461-483.

Boone, H. N. and Boone, D. A. (2012). Analyzing Likert Data. Journal of Extension, 50(2). Article number, 2TOT2

Bowen, G. A. (2009). Document analysis as a qualitative research method. Qualitative Research Journal, 9(2): 27-40

Bracarense, L. S. F. P., Brandãob, R., Yamashitab, Y. and de Aragãob, J. J. G. (2016). Feasibility study for waterway infrastructure: international overview and methodological recommendations. Transportation Research Procedia 18: 305 – 311

Brent, A. C. and Petrick, W. (2007). Environmental impact assessment during project execution phases: towards a stage-gate project management model for the raw materials processing industry of the energy sector. Impact Assessment and Project Appraisal, 25(2): 111–122.

Brouwer, F. and Ittersum, M. K. (2010). Environmental and Agricultural Modelling - Integrated Approaches for Policy Impact Assessment. Springer Science and Business Media, Berlin, Germany.

Brown, A. C., Stern, J., Tenenbaum, B. and Gencer, D. (2006). Handbook for evaluating infrastructure regulatory systems. World Bank. Siteresources.worldbank.org>Resources Accessed 28 February 2019

Brown-Luthango, M. (2011). Capturing land value increment to finance infrastructure investment: Possibilities for South Africa. Urban Forum, 22:37-52.

Bryce, J. M. (2008). Developing sustainable transportation infrastructure: Exploring the Development and Implementation of a Green Highway Rating System. ASTM WISE Intern.www.wise-intern.org/journal/2008/jamesbrycefinal.pdf Accessed 24 September 2016

Bueno, P. C., Vassallo, J. M., and Chueng, K. (2015). Sustainability assessment of transport infrastructure projects: A review of tools and methods. Transport Reviews, 35(5): 622-649

Burger, M. (2013). Project management in the built environment: the need for industry specific knowledge. Unpublished Doctoral Thesis. University of the Free State, South Africa.

Burnard, P., Gill, P., Stewart, K., Treasure, E. and Chadwick, B. (2008). Analysing and interpreting qualitative data. British Dental Journal, 204(8): 429-432

Byaruhanga, A. and Basheka, B. C. (2017). Contractor Monitoring and Performance of Road Infrastructure Projects in Uganda: A Management Model. Journal of Building Consturction and Planning Research, 5 (1): 30-44.

Byrne, B. M. (2001). Structural equation modelling with AMOS: Basic concepts, applications and programming. In: Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) Lawrence Erlbaum, Mahwah New Jersey, London.

Byrne, B. M. (2006). Structural equation modeling with EQS: Basic concepts, applications and programming. 2nd ed. Lawrence Erlbaum Associates, Mahwah.

Canterelli, C. C., Flyvberg, B. Molin, E. J. E., van Wee, B. (2010). Cost overruns in large scale transport infrastructure projects: explanations and their theoretical embeddedness. European Journal of Transport and Infrastructure Research, 10(1): 5-18

Carter, L. (2015). Five secrets of success of sub-Saharan Africa's first road PPP. The World Bank. https://blogs.worldbank.org/ppps/five-secrets-success-sub-saharan-africa-s-first-road-ppp Accessed 03 October 2016

Carter, R. L. (2006). Solutions for missing data in structural equation modeling. Research and Practice in Assessment, 1(1):1-6.

Cascetta, E., and Pagliara, F. (2013). Public engagement for planning and designing transportation systems. Procedia – Social and Behavioural Sciences, 87: 103-116

Cascetta, E., Cartenì, A., Pagliara, F. and Montanino, M. (2015). A new look at planning and designing transportation systems: A decision-making model based on cognitive rationality, stakeholder engagement and quantitative methods. Transport Policy, 38: 27–39

Castro, F. G., Kellison, J. G., Boyd, S. J. and Kopak, A. (2010). A methodology for conducting integrative mixed methods research and data analyses. J Mix Methods Res, 4(4): 342-360

Cervero, R. (2011). Beyond travel time savings: An expanded framework for evaluating urban transport projects. World Bank. https://pdfs.semanticscholar.org/9617/0c7534cfc44668e69130ec49e9718e5d3cfb.pdf Accessed 16 June 2017

Chan, L. L. and Idris, N. (2017). Validity and Reliability of The Instrument Using Exploratory Factor Analysis and Cronbach's alpha. .International Journal of Academic Research in Business and Social Sciences, 7(10), pages 400-410

Charmaz, K. (2006). Constructing Grounded Theory: A Practical Guide through Qualitative Analysis. Thousand Oaks: Sage.

Chatziioannou, I. and Alvarez-Icaza, L. (2017). Evaluation of the urban transportation infrastructure and its urban surroundings in the Iztapalapa County: A geotechnology approach about its management. Cogent Engineering, 4(1): 1330854

Che, X, Shang, J. and Wang, J. (2002). Strategic environmental assessment and its development in China. Environmental Assessment Review, 22(2): 101-109

Chen, D. and Cruz, P. (2012). Performance of transport infrastructure. J. Perform. Constr. Facil., 26(2): 136-137.

Chetty, P. (2015). Interpretation of factor analysis using SPSS. https://www.projectguru.in/publications/interpretation-of-factor-analysis-using-spss/ Accessed 20 November 2018

Chinda, T. and Mohamed, S. (2007). Structural equation model of construction safety culture. Engineering, Construction and Architectural Management, 15(2): 114-131.

Columbia Broadcasting System (CBS) (2010). America's failing infrastructure. 4 September 2010. https://www.youtube.com/watch?v=YO-NObj_TrQ. Accessed 24 September 2016

Cornet, Y. (2016). Indicators and beyond: Assessing the sustainability of transport projects. Unpublished Doctoral Thesis. Technical University of Denmark, Kgs. Lyngby

Cornet, Y., Barradale, M. J., Gudmundsson, H. and Barford, M. B. (2018). Engaging multiple actors in large-scale transport infrastructure project appraisal: An application of MAMCA to the Case of HS2 high-speed rail. Journal of Advanced Transportation, doi: 10.1155/2018/9267306

Costello, A. B., and Osbourne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. Practical Assessment, Research and Evaluation, 10(7): 1-9

Cottrill, C. D. and Derrible, S. (2015). Leveraging big data for the development of transport sustainability indicators. Journal of Urban Technology 22(1): 45-64.

Crescenzi, R., Di Cataldo, M. and Rodríguez-Pose, A (2016) Government quality and the economic returns of transport infrastructure investment in European regions. Journal of Regional Science, 10.1111/jors.12264. pp. 1-51

Creswell, J. W. (2013). Five qualitative approaches to inquiry. Ch. 4 In: Qualitative Inquiry and Research Design. https://www.sagepub.com/sites/default/files/upm-binaries/13421_Chapter4.pdf Sage Publications.

Creswell, J. W. (2014). Research design: Qualitative, quantitative and mixed methods approaches. 4th ed. Sage Publications, California.

Crowe, S. Creswell, K, Robertson, A., Huby, G., Avery, A. and Sheik, A. (2011). The case study approach. BMC Med Res Methodol, 11: 100

Crowson, M. (2016). Path analysis using latent variables using AMOS. https://www.youtube.com/watch?v=lydl-PUNpss Accessed 31 December 2018

Crowson, M. (2018). Assessing and managing non-normality in SEM using AMOS. https://www.youtube.com/watch?v=ZkOCgisnRfQ Accessed 31 December 2018

Cruzes, D. S., Dyba, T, Runeson, P. and Host, M. (2014). Case studies synthesis: A thematic, cross-case, and narrative synthesis worked example. Empir Software Eng. Doi: 10.1007/s10664-014-9326-8

Cuttaree, V., Humphreys, M., Muzira, S. and Strand, J-P. (209). Private participation in the transport sector: Lessons from recent experience in Europe and Central Asia. World Bank. http://documents1.worldbank.org/curated/en/731581468101937383/pdf/495130NWP0Priv10Box341963B01PUBLIC1.pdf Accessed 29 December 2018

Darke, P., Shanks, G. and Broadbent, M. (1998). Successfully completing case study research: Combining rigour, relevance and pragmatism. Info Systems J., 8:273-289

De Carvalho, S. (2007). Sustainability index for integrated urban water management (IUWM) in southern African cities. Case study applications: Greater Hermanus region and Maputo City. Unpublished Master's Dissertation. University of Cape Town, South Africa.

De Gruyter, C., Currie. G. and Rose, G. (2017). Measures of Urban Public Transport in Cities: A World Review and Focus on the Asia/Middle East Region. Sustainability, 9: 43. doi:10.3390/su9010043

De Jager, J. and du Plooy, T. (2007). Measuring tangibility and assurance as determinants of service quality for public health care in South Africa. Acta Commercii, 2007: 97-111.

De Reyck, B., Grushka-Cockayne, Y., Fragkos, I., Harrision. J. and Read, D. (2015). Optimism Bias Study Recommended Adjustments to Optimism Bias Uplifts. Final Report. Department for Transport, UK.

Department of National Treasury South Africa (2015). Medium Term Expenditure Framework: Capital Planning Guidelines. www.treasury.gov.za>publications>guidleines Accessed 25 June, 2018

Department of Water Affairs (DWA) (2013). Feasibility Study for a Long Term Solution to address the Acid Mine Drainage associated with the East, Central and West Rand underground mining basins. DWA Pretoria, South Africa. http://www.dwaf.gov.za/Projects/AMDFSLTS/Documents/Report%2010%20Feasibility%20Report.pdf Accessed 25 November 2018

Development Bank of Southern Africa (DBSA) (2012). Infrastructure barometer: Progress in infrastructure development since democracy. DBSA, Development Planning Division, South Africa. https://www.dbsa.org/EN/About-Us/Publications/Documents/Infrastructure%20Barometer%202012.pdf Accessed 06 June 2017

Devkar, G. A., Mahalingam, A., and Kalidindi, S. N. (2009). Analysing the institutional framework for urban PPP in Indian States. Construction Research Congress, 5-7 April. Seattle, Washington, United States.

Dey, P. K. (2001). Integrated approach to project feasibility analysis: A case study. Impact Assessment and Project Appraisal, 19(3): 235-245.

Dhingra, C. (2011). Measuring public transport performance: Lessons for developing cities. Sustainable Urban Transport Technical Document #9. https://www.sutp.org>contents>resources. Accessed 8 June, 2016

Dien, J., Beal, D. J. and Berg, P. (2005). Optimizing principal components analysis of event-related potentials: Matrix type, factor loading weighting, extraction, and rotations. Clinical Neurophysiology 116: 1808–1825

Doke, L. (2015). Investment still needed in transport infrastructure. Special Report. Mail and Guardian. 17 July 2015. https://mg.co.za/article/2015-07-17-investment-still-needed-in-transport-infrastructure Accessed 22 May 2017

Dong, X., Du, X., Li, K., Zeng, S. and Bledsoe, B. P. (2018). Benchmarking sustainability of urban water infrastructure systems in China. Journal of Cleaner Production, 170: 330-338

Du Pisani, J. A. (2006). Sustainable development: Historical roots of the concept. Environmental Sciences, 3(2): 83-96.

Dusek, G. A., Yurova, Y. V., and Ruppel, C. P. (2015). Using Social Media and Targeted Snowball Sampling to Survey a Hard-to-reach Population: A Case Study. International Journal of Doctoral Studies, 10: 279-299.

Dusek, G. A., Yurova, Y. V. and Ruppel, C. P. (2015). Using social media and targeted snowball sampling to survey a hard-to-reach population: A case study. 140 International Journal of Doctoral Studies, 10: 279-299

Edwin Roland Van Teijlingen, E. R. and Hundley, V. (2001). The Importance of Pilot Studies. Nursng Standard, 16(40):33-6

Ehlers, T. (2014). Understanding the challenges for infrastructure finance. BIS Working Papers No 454. Bank for International Settlements https://www.bis.org/publ/work454.pdf Accessed 29 December 2018

Ekmekci, B., McAnany, C. E. and Mura, C. (2016). An Introduction to Programming for Bioscientists: A Python-Based Primer. PLoS Comput Biol. 12(6): e1004867. https://doi.org/10.1371/journal.pcbi.1004867

El-Maaty, A. E. A., Akal, A. Y. and El-Hamrawy, S. (2016). Management of Highway Projects in Egypt through Identifying Factors Influencing Quality Performance. Journal of Construction Engineering. http://dx.doi.org/10.1155/2016/4823630

Erlich, R. (2015). Controversy runs deep in Nicaragua's canal plan. Aljazeera America. 25 February http://america.aljazeera.com/opinions/2015/2/nicaragua-launches-worlds-largest-infrastructure-project.html. Accessed 03 April 2016

Etemadnia, H. and Abdelghany, K. (2011). A distributed origin-destination demand estimation approach for real-time traffic network management. Transportation Planning and Technology, 34(3): 217-230

Etikan, I., Musa, S. A. and Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1): 1-4.

European Union (2014). Guide to Cost-Benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014-2020. https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf Accessed 20 November 2018

European Union (n. d.). Terms of reference for a feasibility study for a standard gauge separate railway line in Estonia, Latvia and Lithuania (Rail Baltica Corridor). http://www.sam.gov.lv/images/modules/items/PDF/item_2605_Terms_of_Reference.pdf Accessed 20 November, 2018.

Fancello, G., Carta, M and Fadda, P. (2014). A modelling tool for measuring the performance of urban road networks. Procedia – Social Behavioural Sciences, 111:559-566

Faturechi, R. and Miller-Hooks, E. (2015). Measuring the performance of transportation infrastructure systems: A comprehensive review. J. Infrastruct. Syst., 21(1): -1—1

Fay, M. and Toman, M. (2010). Infrastructure and Sustainable Development. Korea-World Bank High Level Conference on Post-Crisis Growth and Development. June 3-4, Busan, Korea http://siteresources.worldbank.org/DEC/Resources/84797-1275071905763/Infra_and_Sust_Dev-Fay_and_Tomanr.pdf Accessed 27 May 2017

Federal Highway Administration (FHWA) (2006). The transportation planning process: Key issues. Briefing book for Transportation Decision makers, Officials and Staff. FHWA.

Field, A. (2005). Factor analysis using SPSS. University of Sussex. http://users.sussex.ac.uk/~andyf/factor.pdf Accessed 29 December 2018

Finch, W. H. (2012). Distribution of variables by method of outlier detection. Front Psychol, 3:211

Flyvberg, B. Garbuio, M. and Lovallo, D. (2009). Delusion and deception in large infrastructure projects: Two models for explaining and preventing executive disaster. California Management Review, 51(2): 170-193

Flyvberg, B., Garbuio, M., Lovallo, D. (2014). Better forecasting for large capital projects. McKinsey & Company. December 2014. https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/better-forecasting-for-large-capital-projects. Accessed 10 January 2017

Flyvberg, B., Hon, C. and Fox, W. H. (2016). Reference class forecasting for Hong Kong's major road works projects. Civil Engineering, 169(6): 17-24.

Flyvbjerg B, (2005a). Measuring inaccuracy in travel demand forecasting: methodological considerations regarding ramp up and sampling. Transportation Research A, 39: 522-530

Flyvbjerg, B. (2005b). Policy and planning for large infrastructure projects: Problems, causes, cure. Environment and Planning B: Planning and Design, 34: 578-597

Flyvbjerg, B. (2007a). How optimism bias and strategic misrepresentation in early project development undermine implementation. Concept Report, 17(3): 1-17

Flyvbjerg, B. (2007b). Megaproject policy and planning: problems, causes, cures. Aalborg: Institut for Samfundsudvikling og Planlægning, Aalborg Universitet. http://vbn.aau.dk/files/9176727/Afhandling_2007_Sammenfatning.pdf Accessed 21 August 2018

Flyvbjerg, B. (2014). What You Should Know about Megaprojects and Why: An Overview, Project Management Journal, vol. 45, no. 2, April-May, pp. 6-19, https://arxiv.org/ftp/arxiv/papers/1409/1409.0003.pdf. Accessed 12 June 2018

Flyvbjerg, B., Holm, M. K. S. and Buhl, S. L. (2005). How (In)accurate are Demand Forecasts in Public Works Projects? The Case of Transportation. *Journal of the American Planning Association*, 71: 131–146

Fourie, C. J. and Zhuwaki, N. T. (2017). A modelling framework for railway infrastructure reliability analysis. South African Journal of Industrial Engineering, 28(4): 150-160

Friedrich, E. and Timol, S. (2011). Climate change and urban road transport: A South African case study of vulnerability due to sea level rise. Journal of the South African Institution of Civil Engineering, 53(2):14-22.

Froschauer, P. (2010). An analysis of the South African bus rapid transit (BRT) policy implementation paradigm. 29th South African Transport Conference, 16-19 August, Pretoria South Africa

Frost, J. (2018). Degrees of Freedom in Statistics. http://statisticsbyjim.com/hypothesis-testing/degrees-freedom-statistics/ Accessed 28 December 2018.

Gajendran, C, Serin, V. K., Seenu, S. G. and Swati, P. (2015). Different methods of accident forecast based on real data. Journal of Civil & Environmental Engineering, 5(4): 180

Gamalath, I. M., Perera, H. L. K. and Bandara, J. M. S. J. (2014). Environmental impact assessment of transport infrastructure projects in Sri Lanka: Way forward. Journal of Tropical Forestry and Environment, 4(1): 85-96.

Gao, S., Mokhtarian, P. and Johnston, R. (2008). Non-normality of Data in Structural Equation Models. Transportation Research Record, 2082(1), pp.116-24. https://doi.org/10.3141/2082-14

Gauteng Department of Roads and Transport (GPDRT) (2014). Annual report 2013/2014. GPDRT.

http://www.gauteng.gov.za/government/departments/roa/Annual%20Reports/DRT%20Annual%20Report%20(2013-14).pdf Accessed 10 July 2018

Gauteng Department of Roads and Transport (GPDRT) (2015a). Annual report 2014/2015. https://provincialgovernment.co.za/department_annual/294/2015-gauteng-roads-and-transport-annual-report.pdf Accessed 10 July 2018

Gauteng Department of Roads and Transport (GPDRT) (2015b). Detail Design Report: Construction of bridge 5610 over Tolwane River at road D603. GPDRT.

Gauteng Department of Roads and Transport (GPDRT) (2015c). Hydrological and hydraulic analysis of culvert IDC2673 ON D603: Tributary to Sand River. Storm Water Report. GPDRT.

Gauteng Department of Roads and Transport (GPDRT) (2015d). Tolwane bridge on road d603 near Mabopane, Unit T, Gauteng Bridge Report. GPDRT.

Gauteng Department of Roads and Transport (GPDRT) (2016). Contract No DRT:21/07/2014 for Upgrading and rehabilitation of Cedar Road D1027 from 2.95km Valley Road to 5.93km Runnymead Road Phase 1. GPDRT.

Gauteng Department of Roads and Transport (GPDRT). Annual Report 2012/2013. https://provincialgovernment.co.za/department_annual/40/2013-gauteng-roads-and-transport-annual-report.pdf Accessed 10 July 2018

Gautrain Management Agency (GMA) (2012). Gautrain: From dreams to reality. GMA.

Gautrain Management Agency (GMA) (2018). Performance Committee worksheet and dashboard. January 2018. GMA.

Gautrain Management Agency (GMA) 2015. Case studies. GMA.

Ghasemi, A. and Zahediasl, S. (2012). Normality Tests for Statistical Analysis: A Guide for Non-Statisticians. Int J Endocrinol Metab, 10(2): 486–489.

Ghauri, P. N. and Firth, R. (2009). The formalisation of case study research in international business, Markt, 48: 29-40

Ghosh, I., Chandra S. and Boora, A. (2013). Operational performance measures for two-lane roads: An assessment of methodological alternatives. Procedia – Social and Behavioural Sciences, 104: 440-448

Glaister, S. Allport, R., Brown, R. and Travers, T. (2010). Success and failure in urban transport infrastructure projects. KPMG International. https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-transport-studies/Success-and-Failure-in-Urban-Transport-Infrastructure-Projects.pdf. Accessed 24 September 2016

Global Construction Review (GCR) (2016). Uganda's new $2.6m technical college gets just 17 students. http://www.globalconstructionreview.com/news/ugandas-new-26m-technical-coll7ege-g7ets-ju7st-17/ Accessed 26 October 2018

Godard, X. and Fatonzoun, I. (2002). Urban mobility for all. CRC Press, Florida, United States of America.

Goondiwala, Z., 2014. The Rea Vaya bus rapid transport (BRT) project, s.l.: s.n

Gorham, R. (2002). Air pollution from ground transportation an assessment of causes, strategies and tactics, and proposed actions for the international community. https://www.un.org/esa/gite/csd/gorham.pdf Accessed 18 November 2018

Graham, N. and van Niekerk, B. (2014). Developing a public transport investment assessment framework. South African Cities Network. https://www.sacities.net/wp-content/uploads/2020/03/sacn_public_transport_investment_assessment_framework_-web-2014.pdf Accessed 31 December 2018

Grant, M., Rue, H., Trainor, S., Bauer, J., Parks, J., Raulersson, M., Rooney K and Suter, S. (2012). The role of transportations systems management and operations in supporting liveability and sustainability: A primer. United States: Department of Transport. https://ops.fhwa.dot.gov/publications/fhwahop12004/c1.htm Accessed 24 September, 2016

Grinyer, A. (2009). The ethics of the secondary analysis and further use of qualitative data. Social Research Update, 56:1-4

Griskeicius, A. and Griskeviciute-Geciene, A. (2008). The analysis of the construction costs of transport infrastructure projects. The 8th International Conference on Reliability and Statistics in Transportation and Communication, 15-18 October 2008, Riga, Latvia.

Gromole, V., Yatskiv, I. and Pepulis, J. (2017). Safety and Security of Passenger Terminal: the Case Study of Riga International Coach Terminal. Procedia Engineering, 178: 147-154

Gulyás, A. and Kovács, Á. (2016). Assessment of transport connections based on accessibility. Transportation Research Procedia, 14: 1723-1732

Gummer, T. and Ruβmann, J. (2013). Good questions, bad questions? A post-survey evaluation strategy based on item nonresponse. Survey Methods: Insights from the Field. pp. 6-10. http://surveyinsights.org/?p=2330. Accessed 14 October 2018

Guo, B., Perron, B. E. and Gillespie, D. F. (2009). A systematic review of structural equation modelling in social work research. Br J Soc Work, 39(8): 1556-1574

Haas, R., Felio, G., Lounis, Z., Falls, L. C. (2009). Measurable performance indicators for roads, Canadian and International Practice. Annual Conference of the Transportation Association of Canada, Vancover, British Columbia

Habibzadeh, F. (2017) Statistical Data Editing in Scientific Articles. J Korean Med Sci. 2017 Jul; 32(7): 1072–1076.

Hadi, N. U., Abdullah, N. and Sentosa, I. (2016). Making sense of mediating analysis: A marketing perspective. Review of Integrative Business and Economics Research, 5(2): 62-76.

Hair, J. F., Black, W. C., Babin, B. J. and Anderson, R. E. (2010). Multivariate Data Analysis, Upper Saddle River, NJ: Prentice Hall.

Halil, F. M., Nasir, N. M., Hassan, A. A. and Shukur, A. S. (2016). Feasibility study and economic assessment in green building projects. Procedia – Social and Behavioural Sciences, 222: 56-64

Hampton, L. (2009). An introduction to financing airport infrastructure in the USA and elsewhere. Airport Management, 3(4):320-327.

Han, S., Hwang, H., Kim, S., Baek, G. S. and Park, J. (2015). Sustainable Water Infrastructure Asset Management: A Gap Analysis of Customer and Service Provider Perspectives. Sustainability, 7: 13334-13350

Harris, L. R. and Brown, G. T. L. (2010). Mixing interview and questionnaire methods: Practical problems in aligning data. Practical Assessment, Research and Evaluation, 15(1): 1-19

Hassan, S., Arroyo, J., Galan, J. M., Antunes, L. and Pavon, J. (2013). Asking the oracle: Introducing forecasting principles into agent-based modelling. Journal of Artificial Societies and Social Simulation, 16(3): 13

Hauben, M., Hung, E. and Hsieh, W. (2017). An exploratory factor analysis of the spontaneous reporting of severe cutaneous adverse reactions. Ther Adv Drug Saf, 8(1):4-16.

Hayat, M. J. (2013). Understanding Sample Size Determination in Nursing Research. Western Journal of Nursing Research. https://doi.org/10.1177/0193945913482052

Hayes, A. F. and Preacher, K. J. (2010). Quantifying and testing indirect effects in simple mediation models when the constituent paths are nonlinear. Multivariate Behavioural Research, 45:627-660

Heckathorn, D. D. (2011). Snowball versus respondent-driven sampling. Sociol Methodol, 41(1): 355–366.

Heckathorn, D. D. (2011). Snowball versus respondent-driven sampling. Sociol Methodol. 2011 Aug 1; 41(1): 355–366.

Hickman, R. L.Melissa D. Pinto, M. D. Lee, E. and Daly, B. J. (2012). Exploratory and Confirmatory Factor Analysis of the Decision Regret Scale in Recipients of Internal Cardioverter Defibrillators. J Nurs Meas. 2012; 20(1): 21–34.

Hofisi, C., Hofisi, M. and Mago, S. (2014). Critiquing interviewing as a data collection method. Mediterranean Journal of Social Sciences, 5(16): 60-64

Holt, M. M. and Scariano, S. M. (2009) Mean, Median and Mode from a Decision Perspective, Journal of Statistics Education, 17(3): 1-17

Hooper, D. Z., Coughlan, J., and Mullen, M. R. (2008). Structural equation modelling: Guidelines for determining model fit. The Electronic Journal of Business Research Methods, 6(1): 53-60.

Howard, M. C. (2016). A Review of Exploratory Factor Analysis Decisions and Overview of Current Practices: What We Are Doing and How Can We Improve? *Intl. Journal of Human–Computer Interaction*, 32: 51–62

Hoyle, R. H. and Gottfredson, N. C. (2015). Sample Size Considerations in Prevention Research Applications of Multilevel Modeling and Structural Equation Modeling. Prev Sci. 2015 Oct; 16(7): 987–996.

Hu, C. and Wang, Y. (2010). Bootstrapping in Amos http://www3.nccu.edu.tw/~changya/SEMworkshop/Amos_bootstrapping_20100630.pdf Accessed 24 December 2018

Hu, L. and Bentler, P. M. (1999) Cut-off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives, Structural Equation Modeling, 6:1, 1-55

Hutchins, J. and Sutherland, J. (2008). An Exploration of Measures of Social Sustainability and their Application to Supply Chain Decisions. Journal of Cleaner Production - J CLEAN PROD. 16. 1688-1698. 10.1016/j.jclepro.2008.06.001.

Hyari, K. and Kandil, A. (2009). Validity of feasibility studies for infrastructure contrition projects. Jordan Journal of Civil Engineering, 3(1): 66-79

Iacobucci, D. (2010). Structural equations modelling: Fit indices, sample size and advanced topics. Journal of Consumer Psychology, 20: 90-98

IBM Knowledge Centre (2016). Factor Analysis Descriptives. https://www.ibm.com/support/knowledgecenter/SSLVMB_sub/statistics_mainhelp_ddita/spss/base/idh_fact_des.html Accessed 20 November 2018

Ignaccolo, M., Inturri, G., Garcia-Melon, M., Giuffrida, N, Le Pira, M. and Torrisi, V. (2017). Combining Analytic Hierarchy Process (AHP) with role-playing games for stakeholder engagement in complex transport decisions. Transportation Research Procedia, 27:500-517

In, J. (2017). Introduction of a pilot study. Korean J Anesthesiol., 70(6): 601-605

Infrastructure Consortium for Africa (ICA) (2007). Briefing Memorandum: The Kazungula Bridge Botswana-Zambia. ICA Meeting: Financing Transport for Growth in Africa. ICA Meeting: Financing Transport for Growth in Africa, December 3-4 December. https://www.icafrica.org/fileadmin/documents/Transport_Meeting/S4-Kazungula-Bridge-Final-EN.pdf Accessed 24 September 2016

Ioan, V. (2010). Financing Investment Projects the Relationship between Feasibility Study and Business Plan. Economics and Applied Informatics, 1: 125-130.

Ivankova, N. V., Creswell, J. W. and Stick, S. (2006). Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. Field Methods 18(1):3-20

Jacobson MZ, Howarth RW, Delucchi MA et al (2013) Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight. Energy Policy, 57:585–601

Jarvis, C., MacKenzie, S., and Podsakoff, P. (2003). A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research. Journal of Consumer Research, 30(2), 199-218.

Jayasinghe, R. and Baillie, C. (2017). Engineering with people: A participatory needs and feasibility study of a waste-based composite manufacturing project in Sri Lanka. Ch. 8 In Green Composites. 2nd ed. pp. 149-180.

Jayasinghe-Mudalige, U. K., Udugama, J. M. M. and Ikram, S. M. M. (2012). Use of structural equation modeling techniques to overcome the empirical issues associated with quantification of attitudes and perceptions. Sri Lankan Journal of Applied Statistics, 13:15-37.

Jeerangsuwan, T., Said, H., Kandil, A and Ukkusuri, S. (2014). Financial evaluation for toll projects considering traffic volume and serviceability interactions. Journal of Infrastructure Systems, 20(3): 1-9

Jeon, C. M., Amekudzi, A. A. and Guensler, R. L. (2010). Evaluating plan alternatives for transportation system sustainability: Atlanta Metropolitan Region." International Journal of Sustainable Transportation, 4: 227–247.

Joewono, T. B. and Kubota, H. (2006). Safety and security improvement in public transportation based on public perception in developing countries. IATSS Research, 30(1):86-100

Johnson, R. B., Onwuegbuzie, J. and Turner, L. A. (2007). Towards a definition of mixed methods research. Journal of Mixed Methods Research, 1: 112-133

Johnson, W. (2013). Comprehensive Analysis. In Rotorcraft Aeromechanics (Cambridge Aerospace Series, pp. 915-920). Cambridge: Cambridge University Press

Jones, H., Moura, F. and Domingos, T. (2014). Transport Infrastructure Project Evaluation Using Cost-benefit Analysis. Procedia – Social and Behavioural Sciences, 111: 400-409.

Kaare, K. K. and Koppel, O. (2012). Performance indicators to support evaluation of road investments. Journal of Economic Literature, 018, R42: 88-107

Karlaftis, M. and Kepaptsoglou, K. (2012). Performance measurement in the road sector: A cross-country review of experience. Discussion Paper No. 2012-10, Greece: International Transport Forum. https://www.itf-oecd.org/sites/default/files/docs/dp201210.pdf Accessed 28 June 2016.

Katahira and Engineers International (2013). Draft Feasibility Study Report: Manatuto to Natarbora Road. Timor-Leste Road Network Upgrading Project ADB LOAN NO: 2857-TIM. https://www.adb.org/sites/default/files/linked-documents/46260-002-tim-oth-03.pdf Accessed 28 December 2018

Kavanagh, S. C. and Williams, D. W. (2017). Informed Decision-Making through Forecasting: A Practitioner's Guide to Government Revenue Analysis. Chicago, IL: Government Finance Officers Association.

Kehagia, F. (2009). The implementation of sustainability in highway projects. Int. J. Sus. Dev. Plann, 4(1): 61-69.

Kennedy, L. (2015). The politics and changing paradigm of megaproject in metropolitan cities. Habitat International, 45: 163 -168.

Kenny, D. (2011). Measuring model fit. http://davidakenny.net/cm/fit.htm. Accessed 1 December 2018

Kenny, D. (2015). SEM: Fit. http://davidakenny.net/cm/sem.htm Accessed 31 December 2018

Kenny, D. (2018). Mediation. http://davidakenny.net/cm/mediate.htm Accessed 31 December 2018

Kim J. S. (2000). Students' attitudes and perceptions toward technology. Iowa State University. Retrospective Theses and Dissertations. 13909. https://lib.dr.iastate.edu/rtd/13909. Accessed 10 November 2018

Kim, B. C. (2007). Forecasting project progress and early warning of project overruns with probalistic methods. Unpublished Doctoral Thesis. Texas A&M University.

Kline, B. R. (2005). Principles and practice of structural equation modeling. 2nd ed. New York: The Guildford Press, United States of America.

KPMG (2014). Gautrain: Our journey to a better Gauteng- Economic impact of the Gautrain system and future expansion on the Province. Main Report. November 2014.

Kraul, C. (2015). Nicaragua Canal: A Giant Project With Huge Environmental Costs. https://dialogochino.net/en/infrastructure/2298-nicaragua-canal-a-giant-project-with-huge-environmental-costs/ Accessed 03 April 2016.

Krefting, L. (1991). Rigour in qualitative research: The assessment of trustworthiness. American Journal of Occupational Therapy, 45(3): 214-222

Kuang, A., Tang, Z., Shan, L. (2013). Road Network Capacity Reliability Considering Travel Time Reliability. Procedia - Social and Behavioral Sciences 96 (2013) 1818 – 1827

Kuhi, K., Kaare, K. K. and Koppel, O. (2015). Using probalistic methods for missing data prediction in network industries performance measurement systems. Procedia Engineering, 110: 1348-1353.

Kurt, V. (2018). Infrastructure quality is key for improved passenger satisfaction. https://www.globalrailwayreview.com/article/66241/infrastructure-quality-passenger-satisfaction/ 31 December 2018

Kushner, J. (2016). Controversial Railway Splits Kenya's Parks, Threatens Wildlife. National Geographic. https://www.nationalgeographic.com/science/article/160412-railway-kenya-parks-wildlife. Accessed 31 December 2018

Leung, L. (2015). Validity, reliability and generalisability in qualitative research. J Family Med Prim Care, 4(3): 324-327.

Levitt, R. E. and Eriksson, K. (2016). Developing a governance model for PPP infrastructure service delivery based on lessons from Eastern Australia. n Journal of Organization Design (2016) 5:1-8

Levy, Y. and Ellis, T. J. (2006). Towards a Framework of Literature Review Process in Support of Information Systems Research. Proceedings of the 2006 Informing Science and IT Education Joint Conference. 25-28 June. Manchester, United Kingdom.

Liepziger, D. and Lefevre, B. (2015). Private investment in public transport: success stories from Brazilian cities. World Resources Institute, Washington, United States of America. https://www.wri.org/sites/default/files/15_REP_Overcoming_Barriers-web.pdf Accessed 8 June 2016

Lincoln YS and Guba EG. Naturalistic inquiry. California: Sage Publications; 1985.

Litman, T. (2011). Measuring transportation: Traffic, mobility and accessibility. Victoria Transport Institute.

https://pdfs.semanticscholar.org/5d87/f4fed8e9e681103c7a2e02a8661f3a1e4cb8.pdf Accessed 26 June 2017

Litman, T. (2016). Well Measured: Developing Indicators for Sustainable and Liveable Transport Planning. Victoria Transport Policy Institute. Canada. www.vtpi.org>wellmeas Accessed 31 December 2017

Liu, M., Balali, V., Wei, H. and Pena-Mora, F. A. (2015). Scenario-based multi-criteria prioritisation framework for urban transportation projects. American Journal of Civil Engineering and Architecture, 3(6): 193-199

Liu, Y., Hu, W., Xin, S. and Li, L. (2010). Short-term traffic flow prediction based on genetic BP Neural Network. Tenth International Conference of Chinese Transportation Professionals (ICCTP-2010). 4-8 August, Beijing, China.

Liyanage, C. and Villalba-Romero, F. (2015). Measuring success of PPP transport projects: A cross case analysis of toll roads. Transport Reviews, 35(2): 140-161.

Liyanage, C., Dias, N., Amaratunga, D. and Haigh, R. (2017). Current context of transport sector in South Asia: Recommendations towards a sustainable transportation system. Built Environment Project and Asset Management, 7(5): 490-505

Lockwood, C. M. and MacKinnon, D. (1998). Bootstrapping the standard error of the mediated effect. https://pdfs.semanticscholar.org/081e/286cdd132ba4e914b3411996d544a9d1bd58.pdf Accessed 31 December 2018

Lombard, S., Behrens, R. and Viruly, F. (2017). Value creation around transport infrastructure in South Africa: The case of Gautrain. 36th Southern African Transport Conference, 10-13 July, Pretoria, South Africa.

Luke, R. and Heyns, G., 2013, 'Public transport policy and performance: The results of a South African public opinion poll', Journal of Transport and Supply Chain Management 7(1), Art. #96, 1-8

Lyons, G. and Davidson, C. (2016). Guidance for transport planning and policymaking in the face of an uncertain future. Transportation Research Part A: Policy and Practice, 88:104-116

Mabelo, P. B. and Sunjka, B. P. (2017). Application of systems engineering concepts to enhance project lifecycle methodologies. South African Journal of Industrial Engineering, 28(3): 40-55

Macdonald, E. H. (2007). Evaluation, risk and feasibility, Ch. 9 in *Handbook of Gold Exploration and Evaluation.* Woodhead Publishing: United Kingdom.

Mackenzie, W. and Cusworth, N. (2007). The use and abuse of feasibility studies. Project Evaluation Conference, 19-20 June 2007, Melbourne, Australia.

Mackie, P. J. and Nellthorp, J. (2018) Transport appraisal in a policy context. Ch. 1 in Transport Projects, Programmes and Policies: Evaluation Needs and Capabilities. Ebook. Pearman A.D., Mackie, P. and Nellthorp, J. (eds.). Taylor and Francis Group. Online

MacKinnon, D. P., Lockwood, C. M. and Williams, J. (2004). Confidence Limits for the Indirect Effect: Distribution of the Product and Resampling Methods. Multivariate Behav Res, 39(1):99. 10.1207/s15327906mbr3901_4

Marcelo, D., Mandri-Perrott, C., House, S and Schwartz, J. Z. (2016). An Alternative Approach to Project Selection: The Infrastructure Prioritization Framework. Working Paper of the World Bank Public-Private Partnerships Group. https://www.tralac.org/images/docs/10286/infrastructure-prioritization-framework-an-alternative-approach-to-project-selection-world-bank-april-2016.pdf Accessed 31 December 2018

Marsh, H. W., Hau, K. and Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cut-off values for fit indices and dangers in overgeneralising Hu and Bentler's (1999) findings. Structural Equation Modeling, 11(3); 320-341.

Martin, R. L. and Jo, J. H. (2014). Promoting sustainable infrastructure: A feasibility study analysis of a utility-scale PV covered parking structure. International Journal of Sustainable Building Technology and Urban Development, 5(2):115-118

Mason, M. (2010). Sample Size and Saturation in PhD Studies Using Qualitative Interviews. Forum Qualitative Social Research, 11(3). Art 8

Matsiliza, N. S. (2016). Critical Factors in Respect of Managing the E-Toll Road Project in Gauteng, South Africa. African Journal of Hospitality, Tourism and Leisure, 5 (1): 1-10

Matsunaga, M. (2010). How to factor analyse your data: Do's, don'ts and how-to's. International Journal of Psychological Research, 3(1) 97-110

Matthews, L., Hair, J. and Matthews, R. (2018). PLS-SEM: The holy grail for advances analysis. Marketing Management Journal, 28(1): 1-13.

Matti, S., Dai, H., Fujimori, S., Hanaoka, T. and Zhang R. (2017). Key factors influencing the global passenger transport dynamics using the AIM/transport model. Transportation Research Part D, 55: 373-388

Maunganidze, L. and Del Mistro, R. (2012). The role of bus rapid transit in improving public transport levels of service, particularly for the urban poor users of public transport: a case of Cape Town, South Africa. The 31st Southern African Transport Conference (SATC 2012), 9-12 July, Pretoria, South Africa

Mavridis, D. and Moustaki, I. (2008). Detecting Outliers in Factor Analysis Using the Forward Search Algorithm. Multivariate Behavioural Research, 43(3): 453-475

McGaffin, R. (2011). Value creation? Value capture? An assessment of three different types of transport interchanges. 30th Southern African Transport Conference, 11-14 July, Pretoria, South Africa.

McNally, A. D., Fitzpatrick, A. G., Mirchandani, S., Salmon, M. and Edwards, D. A. (2017). CERCLA-Linked Environmental Impact and Benefit Analysis: Evaluating Remedial Alternatives for the Portland Harbor Superfund Site, Portland, Oregon, USA. Integrated Environmental Assessment and Management, 14(1): 22–31

Mentis, M. (2015). Managing project risks and uncertainties. Forest Ecosystems, 2:2. DOI 10.1186/s40663-014-0026-z

Mercer and Inter-American Development Bank (IDB). (2016). "Building a bridge to sustainable infrastructure: Mapping the global initiatives that are paving the way." https://publications.iadb.org/handle, Accessed 28 November 2017

Merrow, E. (2011). Industrial mega projects: Concepts, strategies and practices for success. John Wiley and Sons, United States.

Meyers, M. D. and Newman, M. (2007). The qualitative interview in IS research: Examining the craft. Information and Organisation, 17:2-26

Mishra, D. P. and Min, J. (2010). Analyzing the relationship between dependent and independent variables in marketing: a comparison of multiple regression with path analysis. Innovative Marketing, 6(3): 113-120.

Mišić, S. and Radujković, M. (2015). Critical drivers of megaprojects success and failure. Procedia Engineering 122: 71-80

Monama, T. (2017). E-tolls a failure, so SANRAL proposes 'Plan B'. IOL News 28 August. https://www.iol.co.za/motoring/industry-news/e-tolls-a-failure-so-sanral-proposes-plan-b-10965599 Accessed 20 December 2018

Montgomery, R., Schirmer, H. and Hirsch, A. (2015). Improving environmental sustainability in road projects. Environment and Natural Resources. Global Practice Discussion Paper 02. February 2015. Washington DC: World Bank http://documents.worldbank.org/curated/en/220111468272038921/Improving-environmental-sustainability-in-road-projects Accessed 8 January 2018

Morrison, T. G., Morrison, M. A., and McCutcheon, J. M. (2017). Best Practice Recommendations for Using Structural Equation Modelling in Psychological Research. Psychology, 8: 1326-1341

Morse, J. N., Barrett, M., Mayan, M., Olson, K. and Spiers, J. (2002), Verification strategies for establishing reliability and validity in qualitative research. International Journal of Qualitative Methods, 1(2): 13-22.

Muca, M., Puka, L., Bani, K. and Shahu, E. (2013). Principal components and the maximum likelihood methods as tools to analyze large data with a psychological testing example. European Scientific Journal, 9(20): 176-184

Mukherjee, M and Roy, S. (2017). Feasibility studies and important aspect of project management. International Journal of Advanced Engineering and Management, 2(4): 98-100

Muskin, J. A. (2017). Sustainability in development projects: How do we do it and how do we want to? In: The Practice of International Development, Kielson, J. and Gubser, M. (eds.). Routledge, Oxfordshire, United Kingdom.

Musonda, I. (2012). Construction health and safety (H&S) performance improvements: A client-centred model. Unpublished Doctoral Thesis. University of Johannesburg, South Africa.

Musonda, I., Gumbo, T., Bwanyire, B., Musakwa, W., Okoro, C. and Gil, N. (2019). No One-Size Fits-All Organisational Solution: Learning from Railway Developments in South Africa and Ethiopia. In: Dualities by Design: The Global Race to Build Africa's Infrastructure. Editors N. Gil, A. Stafford, and I. Musonda. Cambridge University Press. In press

Mwemezi, B. R. and Luvara, V. G. M. (2017). Reliability of the environmental feasibility studies to the mining and construction projects: A case of Mara river basin in Tanzania. American Journal of Environmental Engineering, 7(3): 65-72.

Nagae, T. and Wakabayashi, H. (2015). Differences in network reliability improvement by several importance indices. Transportation Research Procedia, 10: 155-165.

Nallet, C. (2018). The challenge of urban mobility: A case study of Addis Ababa Light Rail, Ethiopia.https://www.ifri.org/sites/default/files/atoms/files/nallet_urban_mobility_addis_ababa_2018.pdf Accessed 02 August 2018

Naoum, S. G. (2007). Dissertation Research and Writing for Construction Students (2nd ed.) Oxford, UK: Butterworth-Heinemann.

Naser, H. A. (2012). Evaluation of the environmental impact assessment system in Bahrain. Journal of Environmental Protection, 3: 233-239

Neeraj, S. and Kazal, S. Geometric Design of Highway. International Journal of Engineering, Management, Humanities and Social Sciences Paradigms, 14(1).

Nematollahi, O. and Kim, K. C. (2017). A feasibility study of solar energy in South Korea. Renewable and Sustainable Energy Reviews, 77(C): 566-579

Nicolaides, G. (2016). Gautrain needs 48 more carriages to keep up with current demand. Eyewitness News. 12 January. Accessed 7 June, 2016

Nicolaisen, M. S. and Driscoll, P. A. (2014). Ex-post evaluations of demand forecast accuracy: A literature review. Transport Reviews, 34(4):540-557.

Nicolaisen, M. S., Ambrasaite, I. and Salling, K. M. (2012). Forecasts: Uncertain, inaccurate and biased? Proceedings of the Annual Transport Conference. Aalborg University, Denmark.

Nokelainen, P. (2007). Structural equation modeling with AMOS. Research Centre for Vocational Education. Accessed 29 November, 2018.

Nulty, D. D. (2008). The adequacy of response rates to online and paper surveys: what can be done? Assessment and Evaluation in Higher Education, 33(3): 301-314

Nulty, D. D. (2008). The adequacy of response rates to online and paper surveys: what can be done? Assessment & Evaluation in Higher Education, 33(3).

Nuzzolo, A. and Comi, A. (2014). City logistics planning: demand modelling requirements for direct effect forecasting. Procedia – Social and Behavioural Sciences. 125: 239-250.

Ohio Department of Transportation (2017). Feasibility studies and alternative evaluation reports: Documenting decision-making in ODOT's project development process. http://www.dot.state.oh.us/projects/pdp/PDP%20Resources/FeasibilityStudy_AER_Guidance.pdf Accessed 27 July 2018.

Olson, K. (2010). An examination of questionnaire evaluation by expert reviewers. Field Methods, 22(4): 295-318

Oltmann, S. M. (2016). Qualitative interviews: a methodological discussion of the interviewer and respondent contexts. Forum: Qualitative Social Research, 17(2), Art. 15. http://nbn-resolving.de/urn:nbn:de:0114-fqs1602156

Organisation for Economic Co-operation and Development (OECD) (2015). Towards a framework for the governance of infrastructure. Public Governance and Territorial Development Directorate, OECD. https://www.oecd.org/gov/budgeting/Towards-a-Framework-for-the-Governance-of-Infrastructure.pdf Accessed 19 June 2017

Osborne, J. W. (2014). Best Practices in Exploratory Factor Analysis. Scotts Valley, CA: Create Space Independent Publishing.

Osborne, J. W. (2014). Best Practices in Exploratory Factor Analysis. Scotts Valley, CA: CreateSpace Independent Publishing.

Osei-Kyei, R. and Chan, A. P. C. (2016). Developing transport infrastructure in sub-Saharan Africa through PPPs: Policy, practice and implications. Transport Reviews, 36(2): 170-186

Oswald, M. R. and McNeil, S. (2010). Rating sustainability: Transportation Investments in urban corridors as a case study. Journal of Urban Planning and Development, 136(3): 177-185.

Oxford Leaner's Dictionary (2019: online). Comprehensive. Oxford University Press. https://www.oxfordlearnersdictionaries.com/definition/english/comprehensive_1 Accessed 05 July 2019

Pallant, J. (2013). SPSS survival manual: A step by step guide to data analysis using IBM SPSS. 5 th edition. Allen and Unwin, Australia.

Palmer, I., Graham, N., Swilling, M., Robinson, B., Eales, K., Fisher-Jeffes, L., Käsner, S. and Skeen, J. (2013). South Africa's urban infrastructure challenge. Cooperative Governance and Traditional affairs (COGTA) https://www.cogta.gov.za>uploads>2016/05 Accessed 27 July 2017

Palmer, R. and Bishop, B. (2016). Integrated frameworks for infrastructure sustainability. Discussion Paper. December 2016. http://www.wsp-pb.com/Globaln/WSP_Asia_Pacific/News/Report_Integrated%20Frameworks%20for%20Infrastructure%20Sustainability.pdf Accessed May 20 2017

Palvia, P. and Palvia, S. "The Feasibility Study in Information Systems: An Analysis of Criteria and Contents," Information & Management, Vol. 14 (1988), pp. 211-224.

Parthasarathi, P. and Levinson, D. (2010). Post construction evaluation of traffic forecast accuracy. Transport Policy, 17(6): 428-443.

Pârvu, D. and Voicu-Olteanu, C. (2009). Advantages and limitations of the public private partnerships and the possibility of using them in Romania. Transylvanian Review of Administrative Sciences, 27E/2009: 189-198

Pavlina, P. (2015). The Factors Influencing Satisfaction with Public City Transport: A Structural Equation Modelling Approach. Journal of Competitiveness, 7(4): 18 – 32.

Peacock, B. (2016). Gautrain stations signal higher property prices. Sunday Times, Business Times, 07 February 2016. Pp. 4. https://barrow.co.za>uploads>2016/08Accessed 29 July 2018

Pillay, K. and Seedat, I. (2007). Towards 2020: Public transport strategy and action plan. Proceedings of the 26th Southern African Transport Conference (SATC 2007) 9 - 12 July, Pretoria, South Africa.

Pinard, M. I. (2014). Road Management Policy: An Approach to the Evaluation of Road Agency Performance. World Bank. http://documents1.worldbank.org/curated/ar/493221468008120602/pdf/95605-REVISED-WP-PUBLIC-Box391432B-SSATPWP105-RM-PUBLIC.pdf Accessed 31 December 2018

Pohlmann, J. (2004). Use and Interpretation of Factor Analysis in "The Journal of Educational Research": 1992–2002. *The Journal of Educational Research*, *98*(1), 14-22

Pojani, D. and Stead, D. (2015). Sustainable urban transport in the developing world: Beyond megacities. Sustainability, 7: 7784-7805.

Polit, D. F. and Beck, C. T. (2010). Generalisation in quantitative and qualitative research: myths and strategies. Int J Nurs Stud, 47(11):1451-1458

Polzin, S. E. (2002). Security considerations in transportation planning: A white paper. Centre for Urban Transportation Research. https://www.planning.dot.gov/documents/SecurityPapers/SecurityConsiderations_Polzin.pdf Accessed 31 December 2018

Pottas, A. (2013). Addressing Africa's infrastructure challenges. Deloitte. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/dttl-er-africasinfrastructure-08082013.pdf Accessed 17 May 2017

Pregnolato, M., Ford, A, Wilkinson, S. M. and Dawson, R. J. (2017). The impact of flooding on road transport: A depth-disruption function. Transportation Research Part D: Transport and Environment 2017, 55, 67-81.

Prokopowicz, A. K. (2014). The value for money for transport infrastructure projects and its marketing components – Conceptual thoughts and reflections. Management and Business Administration, 22(4): 179-193.

Pupovac V, Petrovecki M. (2011). Summarizing and presenting numerical data. Biochem Med (Zagreb), 21(2):106-10.

Quium, A. S. M. A. (2014). The institutional environment for sustainable transport development. UNESCAP.https://www.unescap.org/sites/default/files/Article%204_Institutional%20environment%20for%20sustainable%20transport%20development.pdf Assessed 20 March 2018

Ramani, T., Zietsman, J., Eisele, W., Rosa, D. Spillane, D. and Bochner, B. (2009). Developing sustainable transportation performance measures for Texas Department of Transportation's Strategic Plan. Technical report. http://static.tti.tamu.edu/documents/0-5541-1.pdf. Accessed 7 June 2016

Ramdhani, A., Ramdhani, M. A. and Amin, A. S. (2014). Writing a Literature Review Research Paper: A step-by-step approach. International Journal of Basic and Applied Science, 3(1): 47-56

Randolph, D. A. (2016). Addressing the social, economic and environmental impacts brought about by infrastructure development in an environmental justice community. International Conference on Transportation and Development, 26-29 June, Houston, Texas.

Rawal, T. and Devadas, V. (2012). Sustainability assessment of Ahmedabad bus rapid transit system. National conference on Sustainable Cities in Arid Region: Planning, Design and Management December 26-28 2012, MNIT – Jaipur

Regan, M. (2017). Capital markets, infrastructure investments and growth in the Asia Pacific Region. International Journal of Financial Studies, 5(5): 1-28

Reid S. and Mash B. (2014). African Primary Care Research: Qualitative interviewing in primary care. Afr J Prm Health Care Fam Med., 6(1), Art. #632: 1-6

Reja, U., Manfreda, K. L., Hlebec, V. and Vehovar, V. (2003). Open-ended vs. Close-ended Questions in Web Questionnaires. Developments in Applied Statistics, 19: 159-177

Republic of South Africa (2018). The study on global competitiveness by reducing transport costs. https://www.saboa.co.za/index_htm_files/Study%20on%20Global%20Competitiveness%20by%20Reducing%20Transport%20Costs%20-%20Consolidated%20Report.pdf Accessed 25 June 2019

Rietveld, P. and Stough, R. (2006). Institutions, regulations and sustainable transport: A review. EJTIR, 6(1):99-112

Ro, H. K., Merson, D., Lattuca, L. R., and Terenzini, P. T. (2015). Validity of the contextual competence scale for engineering students. Journal of Engineering Education, 104 (1): 35–54.

Robbins, G. (2015). The Dube Trade Port-King Shaka International Airport mega-project: Exploring impacts in the context of multi-scalar governance processes. Habitat International, 45(3): 196-204.

Rose, S., Spinks, N. and Canhoto, A. I. (eds.) (2015). Quantitative content analysis. In Management Research: Applying the principles. ch. 6.

Rosenthal, A., Verutes, G., McKenzie, E., Arkema, K. K., Bhagabati, N., Bremer, L. L., Olwero, N. and Vogl, A. L. (2015). Process matters: A framework for conducting decision-relevant assessments of ecosystem services. International Journal of Biodiversity Science, Ecosystem Services and Management, 11(3): 190-204

Rousseeuw P. J., van Driessen K. (1999). A fast algorithm for the minimum covariance determinant estimator. Technometrics, 41: 212–223

Rowley, J. and Slack, F. (2004). Conducting a literature review. Management Research News, 27(6), 31–39

Roxas, N. R., Fillone, A. and Chalermpong, S. (2015). Cost overruns and the proposed Pany-Gimaras-Negros Inter-Island Bridge project, Philippines. Journal of Traffic and Logistics Engineering, 3(1): 81-86.

Rudžianskaitė-Kvaraciejienė, R., Apanavičiene, R. and Gelžinis, A. (2015). Monitoring the effectiveness of PPP road infrastructure projects by applying random forests. Journal of Civil Engineering and Management, 21(3):290-299.

Rummel, R. J. (1970). Understanding factor analysis. https://www.hawaii.edu/powerkills/UFA.HTM Accessed 25 June 2019.

Sabatino, C. (2017). Light rail transportation systems are built in Ethiopia. Global Delivery Initiative. World Bank. http://www.globaldeliveryinitiative.org/library/case-studies/light-rail-transportation-systems-are-built-ethiopia Accessed 18 August 2018.

Salet, W., Bertolini, L. and Giezen, M. (2013). Complexity and uncertainty: Problem or asset in decision making of mega infrastructure projects. International Journal of Urban and Regional Research, 37(6):1984-2000.

Salling K. B. (2013). A New Approach to Feasibility Risk Assessment within Transport Infrastructure Appraisal. Procedia - Social and Behavioural Sciences, 74: 468 – 477

Salling, K. M. and Leleur, S. (2012). Modelling of transport project uncertainties: Feasibility risk assessment and scenario analysis. EJTIR, 12(1): 21-38

Salman, A. F. M., Skibniewskin, M J. and Bosha, I. (2007). BOT viability model for large-scale infrastructure projects. Journal of Construction Engineering and Management, 133(1): 50-63

Saudi, M. M. H. (2014). The effects of the performance management system and the organisational culture on the employees' attitude in Malaysian government statutory bodies: A case study of Majlis Amanah Rakyat (MARA), Unpublished Doctoral Thesis, Southern Cross University, Lismore, NSW.

Scanlon, J. and Davis, A. (2011). The role of sustainability advisers in developing sustainability outcomes for an infrastructure project: Lessons from the Australian Urban Rail Sector, Impact Assessment and Project Appraisal, 29(2) 121.

Schiff, A., Small, J. and Ensor, M. (2013). Infrastructure performance indicator framework development. Covec and Beca. https://treasury.govt.nz/sites/default/files/2017-12/ipifd-mar13.pdf Accessed 4 January 2017

Schippl, J. (2016) "Assessing the desirability and feasibility of scenarios on eco-efficient transport: a heuristic for efficient stakeholder involvement during foresight processes", Foresight, 18(1): 41-58

Schneider-Roos, K., Wiener, D., Guldiman, R. and Grossman, M. (2014). Unleashing private capital investments for sustainable infrastructure greenfield projects: Scoping study regarding the early stage project preparation phase. Global Infrastructure Basel Foundation. Switzerland. www.gib-foundation.org Accessed 26 June 2018

Schreiber, J. B., Stage, F. K., King, J., Nora, A. and Barlow, E. A. (2006). Reporting structural equation modeling and confirmatory factor analysis: A review. Journal of Educational Research, 99(6):323-338.

Schuckmann, S. W., Gnatzy, T., Darkow, I. and von der Gracht, H. A. (2012). Analysis of factors influencing the development of transport infrastructure until the year 203: A delphi-based scenario study. Technological Forecasting and Social Change, 79(8): 1373-1387

Schutte, I. C. and Brits, A. (2012). Prioritising transport infrastructure projects: Towards a multi-criterion analysis. Southern African Business Review, 16(3): 97 – 117

Serero, G. Van Jaarsveld, G., De Abreu, V. and Brislin, A. (2015). Feasibility study on traffic decongestion strategies at Maseru bridge border post. The 34th Southern African Transport Conference (SATC 2015), 6-9 July, Pretoria South Africa.

Sharma, A. and Strezov, B. (2017). Life cycle environmental and economic impact assessment of alternative transport fuels and power-train technologies. Energy, 133.

Shen, L., Tam, V., Tam, L. and Ji, Y. (2010). Project feasibility study: The key to successful implementation of sustainable and socially responsible construction management practice. Journal of Cleaner Production. 18(3).

Shen, L., Wu, Y. and Zhang, X. (2011). Key assessment indicators for the sustainability of infrastructure projects. Journal of Construction Engineering and Management, 137 (6): 441-451

Shortall, R. (2015). A Sustainability Assessment Framework for Geothermal Energy Developments. Unpublished Doctoral Thesis, University of Iceland, Reykjavík, Iceland.

Siemiatycki, M. 2010. Delivering transportation infrastructure through public-private partnerships: Planning concerns. Journal of the American Planning Association 76: 43 – 58.

Social Research Methods (2013). Qualitative validity. www.socialresearchmethods.net/kb/qualval.php Accessed 13 October 2018.

Soehodho, S. (2017) Public transportation development and traffic accident prevention in Indonesia. IATSS Research, 40(2):76-80

Soliño, A. S. and De Santos, P. G. (2010). Transaction costs in transport public-private partnerships: Comparing procurement procedures. Transport Reviews, 30(3):389-406

Spangenberg, J. H. (2002). Institutional sustainability indicators: an analysis of the institutions in Agenda 21 and a draft set of indicators for monitoring their effectivity. Sustainable Development, 10(2):103-115

Standish, B. and van Zyl, H. (2015). Practice report: Assessing the economic impacts of roads passing through ecologically sensitive areas: A case study in Cape Town, South Africa. Impact Assessment and Project Appraisal, 25(2): 149-156

Stapledon, T. (2012). Why infrastructure sustainability is good for your business. Cooperative Research Centre (CRC) for Infrastructure and Engineering Asset management (CIEAM).https://www.wfeo.org>wp-content>uploads. Accessed 07 January 2018

Stefánsdóttir, A. O. (2015). Feasibility studies in construction projects in Iceland. Unpublished Master's Dissertation. Reykjavík University, Iceland

Steiger, (J. H. (2007). Understanding the limitations of global fit assessment in structural equation modeling. Personality and Individual Difference, 42(5): 893-898.

Stenström, C. (2014). Operation and maintenance performance of rail infrastructure: Model and Methods. Unpublished Doctoral Thesis. Luleå University of Technology, Sweden.

Stewart, J. (2012). Multiple-case study methods in governance-related research. Public Management Review, 14(1): 67-82

Suanmali, S., Kasidis Chankao, K. and Ammarapala. V. (2014). Road Infrastructure and Road User's Satisfactions: A Case Study of Motorway Route 7, Thailand. SHS Web of Conferences, 12: 1-7.

Subash, S. M., Chandrabose, K., Umamaheshwari, U. and Maharajan, T. (2013). Feasibility study of metro transport: Case study Madurai. International Journal of Civil Engineering and Technology, 4(4): 72-83

Sullivan, L. and LaMorte, W. W. (2016). InterQuartile Range (IQR). https://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704_summarizingdata/bs704_summarizingdata7.html Accessed 21 November 2018

Surbeck, C. Q. and Hilger, H. (2014). Social sustainability and important indicators in infrastructure. World Environmental and Water Resources Congress, 1-5 June, Portland, Oregon.

Szolnoki, G. and Hoffmann, D. (2013). Online, face-to-face and telephone surveys: Comparing different sampling methods in wine consumer research. Wine Economics and Policy, 2(2): 57-66

Szüle, B. (2017). Comparison of goodness measures for linear factor structures. Hungarian Statistical Review, 21: 147-163

Taber K. S. (2017). The use of Cronbach's alpha when developing and reporting research instruments in science education. Research in Science Education, doi:10.1007/s11165-016-9602-2. pp. 1-24.

Taber, K. S. (2000). Case studies and generalizability: grounded theory and research in science education. International Journal of Science Education, 22(5): 469-487.

Tánczos, K. and Kong, G. S. (2001). A review of appraisal methodologies of feasibility studies done by public private partnership in road project development. Periodica Polytechnica Ser. Transp. Eng., 29 (1-2): 71–81.

Tayie, S. (2005). Research methods and writing research proposals. Centre for Advancement of Postgraduate Studies and Research on Engineering Sciences, Cairo University (CAPSCU), Egypt.

Titos, G., Lyamani, H., Drinovec, L., Olmo, F. J., Mocnik, G., and Alados-Arbledas, L. (2015). Evaluation of the impact of transportation changes on air quality. Atmospheric Environment, 114: 19-31.

Toth-Szabo, Z. and Várhelyi, A. (2012). Indicator framework for measuring sustainability of transport in the city. Procedia – Social and Behavioural Sciences, 48: 2035 – 2047.

Trochim, W. M. K. (2006). Qualitative validity. Retrieved August 12, 2005 from http://www.socialresearchmethods.net/kb/qualval.htm Accessed 31 December 2018

Tsimplokoukout, K., Sfakianaki, E. and Metaxas, G. (2012). A feasibility study approach for underground railways - A case study: Line 4 of Athens metro. Global Journal of Engineering Education 14(1):91-98

Turner, D. W. (2010). Qualitative interview design: A practical guide for novice investigators. The Qualitative Report, 15(3), 754-760.

Tutors (2015). Reliability and validity testing using CFA.https://www.youtube.com/watch?v=oUGCFSZia4U Accessed 17 December 2018.

Twerefou, D. K., Chinowsky, P., Adjei-Mantey, K. and Strzepek, N. L. (2015). The Economic Impact of Climate Change on Road Infrastructure in Ghana. Sustainability, 7: 11949-11966

Ugboro, I. O., Obeng, K. and Spann, O. (2010). Strategic Planning as an Effective Tool of Strategic Management in Public Sector Organisations: Evidence from Public Transit Organisations. Administration and Society Journal, 43(1): 87-123.

Ugwu, O. O. and Haupt, T. C. (2005). Key performance indicators for infrastructure sustainability: A comparative study between Hong Kong and South Africa. Journal of Engineering, Design and Technology, 3(1): 30-43

United Nations (2015). Feeder road construction in support of trade and market development in South Sudan. United Nations Office for Project Services (UNOPS). 15 June. https://europa.eu>file>download. 31 December 2018

United Nations Economic Commission for Africa (UNECA) (2017). Africa's large infrastructure projects in dire need of funding/implementation capacity. https://www.uneca.org/stories/africa%E2%80%99s-large-infrastructure-projects-dire-need-fundingimplementation-capacity. Accessed 15 July, 2017

United States Department of Transport (USDOT) (2016). Transportation Statistics Annual Report 2015. Bureau of Transportation Statistics. http://www.bv.transports.gouv.qc.ca/per/0953220/20_2015.pdf Accessed 10 May 2017

United States Department of Transport (USDOT) (2017). What is a Sustainable Highway? https://www.sustainablehighways.org/203/what-is-a-sustainable-highway.html Accessed May 10 2017

University of Southern California, (USC) Libraries, 2018. Communication Studies: The Literature Review. http://libguides.usc.edu/c.php?g=234974&p=1559473. Accessed 27 November 2018

Upadhyaya, J. K., Biswas, N. and Tam, E. A review of infrastructure challenges: assessing stormwater system sustainability. Home Canadian Journal of Civil Engineering, 41(6).

Valentin, V., Abraham, D. M., Mannering, F. L., Mostafavi, A. (2012). Assessment of Public Opposition to Infrastructure Developments: The Case of Nuclear Power Projects. Construction Research Congress. May 21-23, West Lafayette, Indiana, United States of America.

Van der Westhuizen, J. (2007). Glitz, glamour and the Gautrain: Megaprojects as political symbols. Politikon, 34(3):333-351.

VanZerr, M. and Seskin, S. (2011). Liveability and quality of life indicators. Recommendations Memo #2. 22, CH2M HILL, USA.

Vasconcellos, E. A. (2014). Urban Transport Environment and Equity: The Case for Developing Countries. Routledge. Oxfordshire. United Kingdom.

Vayalamkuzhi, P. and Amirthalingam, A. (2016). Influence of geometric design characteristics on safety under heterogeneous traffic flow. Journal of Traffic and Transportation Engineering, 3(6): 559-570

Venter and Hayes (2017). South Africa needs to revamp its new public transport system. The Conversation. Public Transport News, 23 October. http://theconversation.com/south-africa-needs-to-revamp-its-new-public-transport-system-84930 Accessed 28 July 2018.

Venter, I. (2013). Martins confirms Gautrain ridership guarantee payments. Engineering News 12 July http://www.engineeringnews.co.za/print-version/gautrain-2013-07-12 Accessed 31 December 2018

Venter, I. (2017). Time to question BRT systems in South Africa, says Vadi, Transport Minister. https://www.engineeringnews.co.za/article/time-to-question-brt-systems-in-south-africa-says-vadi-transport-minister-2017-07-10 Accessed 31 December 2018

Venter, I. (2018). No longer flavour of the month: SA rethinks its bus rapid transit systems. Engineering News 27 July http://www.engineeringnews.co.za/article/no-longer-flavour-of-the-month-sa-rethinks-its-bus-rapid-transit-systems-2018-07-27-1 Accessed 16 October 2018.

Venter, J. H., Burnett, S. L. and Maluleke, K. J. (2001). Gautrain rapid rail link: Integrated Technical Planning, feasibility and business case. The 20th South African Transport Conference, 16 – 20 July, Pretoria, South Africa.

Vera, I., Langlois, L. and Rogner, H. H. (2006). Indicators for sustainable energy development. United Nations. https://www.un.org/esa/sustdev/publications/energy_indicators/chapter2.pdf Accessed 16 October 2018.

Vilana, M. (2014). Department of Transport Presentation to the Gauteng e-toll review panel. Republic of South

Africahttps://www.nra.co.za/content/DOT_Presentation_to_Gauteng_eToll_Review_Panel_Final_Version.pdf Accessed 28 June 2016

Villareal, B., Garza-Reyes, J. A., Kumar, V. and Lim, M. K. (2016). Improving road transport operations through lean thinking: A case study. International Journal of Logistics, doi: 10.1080/13675567.2016.1170773

Viorica I. (2010). Financing Investment Projects the Relationship between Feasibility Study and Business Plan: The Annals of "Dunarea de Jos" University of Galati Fascicle I – 2010. Economics and Applied Informatics. Years XVI – no 1 - ISSN 1584-0409: 125-130

Voice, P. (2014). Comprehensive doctrine. In J. Mandle & D. Reidy (Eds.), The Cambridge Rawls Lexicon (pp. 126-129). Cambridge: Cambridge University Press

Waghmare, A. P. and Pimplikar, S. S. (2012). Risk Analysis In Feasibility Study Of Road Construction Project: Case Study Construction Of The Four Laning Of Amravati – Talegaon Section Nh-6. International Journal of Engineering Research and Applications, 2(3): 3166-3169

Wang, L., Xue, X., Zhao, Z. and Wang, Z. (2018). The impacts of transportation infrastructure on sustainable development: Emerging trends and challenges. International Journal of Environmental Research and Public Health, 15(6). 10.3390/ijerph15061172.

Warmbrod, J. R. (2014). Reporting and interpreting scores derived from Likert-type scales> Journal of Agricultural Education, 55(5): 30-47

Warren, J., Morris, E., Enoch, M., Magdaleno, I. P., Arias, Z. P. and Guanche, J. (2015). Developing an equitable and sustainable mobility strategy for Havana. Cities, (2015):xxx

Wegman, F. and Oppe, S. (2010). Benchmarking road safety performances of countries. Safety Science, 48(9): 1203-1211

Welde, M. and Odeck, J. (2011). Do planners get it right? The accuracy of travel demand forecasting in Norway, EJTIR, 11(1): 80-95

Wey, W. and Wu, K. (2007). Using ANP priorities with goal programming in resource allocation in transportation. Mathematical and Computer Modeling, 46: 985-1000

Whiting, L. S. (2008) Semi-structured interviews: guidance for novice researchers. Nursing Standard. 22, 23, 35-40.

Wiener, D. (2014). Sustainable Infrastructure as an Asset Class. Ecology, Economy and Social Responsibility.

Wolf, E. J., Harrington, K. M., Clark, S. L. and Miller, M. W. (2013). Sample Size Requirements for Structural Equation Models: An Evaluation of Power, Bias, and Solution Propriety. Educ Psychol Meas., 76(6): 913-934.

World Bank (2000). Urban transport and city development. Ch. 2 in Cities on the Move: A World Bank Urban Transport Strategy Review. Siteresources.worldbank.org>chapter2 Accessed 28 February 2019

World Bank (2008). Implementation completion and results report on a loan in the amount of US$280 million to India for the Gujarat State Highway Project. http://documents.worldbank.org/curated/en/606711468033591391/pdf/ICR00006590ICR1Disclosed0Aug0102008.pdf Accessed 15 Jan 2019

World Bank (2010). Sustainability of transport projects: Toolkit http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1239112757744/5997693-1294344242332/Final-Toolkit.pdf Accessed 15 December 2018

World Bank (2013). Improving Institutional Capability and Financial Viability to Sustain Transport An Evaluation of World Bank Group Support Since 2002. http://lnweb90.worldbank.org/OED/OEDDocLib.nsf/DocUNIDViewForJavaSearch/D75BD0BCCB1FB19485257B5700644A7A/$file/Transport_eval.pdf Accessed 29 December 2018

World Bank (2016). PPP arrangements / Types of public-private partnerships. World Bank https://ppp.worldbank.org/public-private-partnership/agreements. Accessed 12 July 2017

World Bank (2017a). Mobile Metropolises: Urban Transport Matters: An IEG Evaluation of the World Bank Group's Support for Urban Transport. http://documents.worldbank.org/curated/en/309551506621356068/pdf/120110-WP-REVISED-PUBLIC.pdf Accessed 20 December 2018

World Bank (2018). Urban sustainability framework (USF). 1st ed. World Bank, Washington DC. http://documents.worldbank.org/curated/en/339851517836894370/Urban-Sustainability-Framework-1st-ed Accessed 29 December 2018

World Bank. (2005). A framework for the economic evaluation of transport projects. Notes on the Economic Evaluation of Transport Projects. http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1227561426235/5611053-1231943010251/trn-5EENote2.pdf. Accessed 29 December 2018

World Bank. (2011). A framework for urban transport benchmarking (English). Washington, DC: World Bank. http://documents.worldbank.org/curated/en/427261468179966551/A-framework-for-urban-transport-benchmarking Accessed 24 September 2017

World Bank. (2014). Public-private partnerships. Reference guide, version 2.0. World Bank. http://documents.worldbank.org/curated/en/600511468336720455/pdf/903840PPP0Refe0Box385311B000PUBLIC0.pdf Accessed 16 January 2018

World Bank. (2017b). Railway reform: Toolkit for improving rail sector performance (English). World Bank Group. Washington DC. http://documents.worldbank.org/curated/en/529921469672181559/Railway-reform-Toolkit-for- improving-rail-sector-performance. Accessed 26 January, 2018

World Commission on Environment and Development (WCED) (1987). Our common future. United Nations. www.undocuments.net/our-common-future.pdf Accessed 24 July 2017

World Economic Forum (2012). Strategic Infrastructure Steps to Prioritize and Deliver Infrastructure Effectively and Efficiently http://www3.weforum.org/docs/WEF_IU_StrategicInfrastructure_Report_2012.pdf Accessed 06 February 2019

Wray, C. and Gotz, G. (eds.) (2014). Mobility in the Gauteng City-Region. Gauteng City-Region Observatory (GCRO). Accessed 25 March 2018.

Writer, S. (2017). South Africa's shocking road death numbers at highest level in 10 years. Business Tech 9 June 2017. https://businesstech.co.za/news/motoring/178275/south-africas-shocking-road-death-numbers-at-highest-level-in-10-years/ Accessed 25 March 2018

Xue, B., Liu, B. and Shu, T. (2018). What matters in achieving infrastructure sustainability through project management practices: A preliminary study of critical factors. Sustainability, 10(12). Doi: 10.3390/su10124421

Yatskiv, I. and Budilovich, E. (2017). Evaluating Riga transport system accessibility. Procedia Engineering, 178: 480-490

Yilmaz, K. (2013). Comparison of quantitative and qualitative research traditions: epistemological, theoretical and methodological difference. European Journal of Education, 48(2): 311-325

Yong, G. A. and Pearce, S. A. (2013). Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis. *Tutor. Quant. Methods Psychol.* 9, 79–94

Yun, S. and Caldas, C. H. (2009). Analysing decision variables that influence preliminary feasibility studies using data mining techniques. Construction Management and Economics, 27: 73-87

Zaiontz, C. (2014). Real statistics using EXCEL. https://www.real-statistics.com/reliability/internal-consistency-reliability/cronbachs-alpha/cronbachs-alpha-basic-concepts/ Accessed 31 December 2018

Zavrl, M. S. and Zeren, M. T. (2010). "Sustainability of urban infrastructure." Sustainability 2:2950-2964.

Zen C. (2007). The only thing unchanged is change: Assess whole SEM model – chi-square and fit index. http://zencaroline.blogspot.com/2007/04/global -model-fit.html

Zhou, J. (2012). Sustainable transportation in the US: A review of proposals, policies and programs since 2000. Frontiers of Architectural Research, 1: 150-165

Zijlstra W. P., van der Ark L. A., Sijtsmal K. (2011). Outliers in questionnaire data: can they be detected and should they be removed? J. Educ. Behav. Stat. 36, 186–212

Zohrabi, R (2013). Mixed methods research: Instruments, validity, reliability and reporting findings. Theory and Practice in Language Studies, 3(2): 254-262.

Zou, P. X. W., Wang, S. Q. and Fang, D. (2008). A life-cycle risk management framework for PPP infrastructure projects. Journal of Financial Management of Property and Construction, 13(2): 123-142

Zou, S., Peng, Y. and Mei, Z. (2011). Research on the new methods of forecasting model of urban passenger traffic mode. 11th International Conference of Chinese Transportation Professionals (ICCTP), 14-17 August, Nanjing, China.

Zuofa, T. and Ochieng, E. G. (2014). Project failure: The way forward. International Journal of Business and Management, 9(11): 59-71.

APPENDIX I - INTRODUCTORY LETTER FOR RESEARCH

6/3/2018

Dear Sir/Madam,

LETTER OF INTRODUCTION FOR DOCTORAL RESEARCH – CHIOMA OKORO

Mrs Chioma Sylvia Okoro is a Doctoral Candidate undertaking research on transportation infrastructure planning and sustainability. The project has been approved by the University of Johannesburg's Ethics Committee. The research project seeks to understand how feasibility studies are conducted and how they can be improved and hence contribute to sustainability of transportation infrastructure projects. The reports on the feasibility studies undertaken on particular transportation infrastructure projects are sought. Additionally, information on the performance of the projects, currently, is required.

We hereby request that you grant Chioma Okoro access to the reports, which we understand may contain sensitive information. In addition, the research would require information from personnel in the planning and management sections of the organisation. The data amassed during the research will be used for research purposes only.

Please contact any of the undersigned, Research supervisor, and/or Head of Postgraduate School of Engineering Management.

Kind regards,

PROF. INNOCENT MUSONDA Ph.D.

Director: Centre of Applied Research + Innovation in the Built Environment (CARINBE)
Associate Professor: Construction Management and Quantity Surveying
Faculty of Engineering and Built Environment
Tel +27 11 559 6655
Email: imusonda@uj.ac.za

PROF. JAN-HARM PRETORIUS Ph.D.

Head of School: APK Postgraduate School of Engineering Management
Head of Department: Engineering Management
Faculty of Engineering and Built Environment
Tel +27 11 559 1730
Email: jhcpretorius@uj.ac.za

APPENDIX II - CONSENT LETTERS

GAUTENG PROVINCE
ROADS AND TRANSPORT
REPUBLIC OF SOUTH AFRICA

To: Prof. Jan-Harm Pretorius
Head of School: APK Postgraduate School of Engineering Management
Head of Department: Engineering Management
Faculty of Engineering and Built Environment

Cc: Prof. Innocent Musonda (Research Supervisor)
Associate Professor: Construction Management and Quantity Surveying
Faculty of Engineering and Built Environment
University of Johannesburg

22nd of March 2018

Good day,

RE: CONSENT TO ACCESS INFORMATION ON TRANSPORTATION INFRASTRUCTURE FEASBILITY REPORTS FOR DOCTORAL RESEARCH BY CHIOMA SYLVIA OKORO

This letter serves as consent granting Chioma Sylvia Okoro permission to access reports on feasibility studies for transportation infrastructure projects in the Gauteng Province, towards her doctoral research.

Kind regards

Freeman Masuku
Chief Director: Transport Policy and Planning
Gauteng Department of Roads and Transport

City of Johannesburg
Johannesburg Roads Agency

66 Pixley Ka Isaka Seme Street
Cnr. Rahima Moosa Street
Johannesburg
2001

P/Bag X70
Braamfontein
South Africa
2017

Tel +27(0) 11 298 5000
Fax +27(0) 11 298 5178
www.jra.org.za
www.joburg.org.za

Mrs Chioma Sylvia Okoro
Doctoral Candidate Student
University of Johannesburg

Dear Mrs Okoro

RE: REQUEST TO CONDUCT RESEARCH AT JRA

1. Your memo dated 06 March 2018 is acknowledged.

2. Your request to conduct research at the Johannesburg Roads Agency towards the **'Transportation Infrastructure Planning and Sustainability'** in the JRA is granted subject to the following conditions:

2.1 That you first submit to the JRA the questionnaire to be used during interviews with the JRA employees.
2.2 That the topic of your research project will contribute to enhance the JRA approach to Transportation Infrastructure Planning and Sustainability.
2.3 That you submit a copy of the research report to the JRA upon completion.

3. We are looking forward to the final product of your research results.

4. We hope that the information gathered during the research exercise will be treated with utmost confidentiality.

Yours Sincerely,

Goodwill Mbatha
Acting Managing Director

Date: 23 APR 2018

City of Johannesburg
Department of Corporate & Shared Services
Office of the Group Head: Group Human Capital Management

6th Floor, B Block
Metropolitan Centre
158 Civic Boulevard
Braamfontein

PO Box 1049
Johannesburg
South Africa
2000

Tel +27(0) 11 407 6926
Fax +27(0) 11 339 1878

www.joburg.org.za

Memorandum

TO	:	Chioma Okoro University of Johannesburg PHD in Engineering Management
FROM	:	Enoch Mafuyeka Deputy Director: Employee Relations and Development
DATE	:	21 May 2018
SUBJECT	:	**RESPONSE ON THE REQUEST TO CONDUCT A RESEARCH ON TOPIC "TRANSPORTATION INFRASTRUCTURE PLANNING AND SUSTAINABILITY"**

The above matter refers to the letter received on the 18 May 2018 in which a request was made to conduct a research in the City of Johannesburg.

The City of Johannesburg hereby grants permission to conduct the above-mentioned study, on the provision that proof of granting ethical clearance be provided prior to commencement of the study.

Please note that on completion of the study, a copy of the research report should be submitted to the City of Johannesburg in honour of your commitment.

The City of Johannesburg wishes you the best during the period of research.

Please do not hesitate to contact us if we can be of further assistance.

Kind Regards

Enoch Mafuyeka
Deputy Director: Employee Relations and Development
Tel: (011) 407-7250
Email: Enochm@joburg.org.za

21/05/2018

APPENDIX III - INTERVIEW GUIDE

INTERVIEW COVER LETTER

19 February, 2018

Department of Engineering Management
University of Johannesburg
Johannesburg

Dear Sir/Madam,

<u>INVITATION TO PARTICIPATE IN A RESEARCH INTERVIEW</u>

I am a Doctoral Candidate undertaking research on transportation infrastructure planning and sustainability. The project, which is sponsored by the University, has been approved by the university's Ethics Committee. The experiences of built environment professionals involved in feasibility studies and management of transportation infrastructure projects are sought. The results are expected to contribute towards the sustainability of transportation infrastructure projects.

You are therefore kindly requested to take part in the study. Participation is voluntary and the responses will be kept confidential. The expected duration of the interview is about 20 minutes. I would be grateful if you could participate in the study.

For any queries regarding the research, please contact the undersigned or research supervisor, Prof Innocent Musonda on +277115596655; imusonda@uj.ac.za.

Chioma S. Okoro
Ph.D. Candidate
Tel: +27738626360; Email: chiomasokoro@gmail.com

INTERVIEW QUESTIONS ON FEASIBILITY STUDY AND TRANSPORTATION INFRASTRUCTURE SUSTAINABILITY

<u>1.0 Profile of respondents</u>

1.1 What organisation do you represent (public or private or other)?

1.2 What is your position in the organisation?

1.3 How long have you been involved in the transportation infrastructure sector?

1.4 What type of transportation infrastructure project were/are you involved in?

1.5 What was your role on the project?

1.6 At what stage were/are you involved?

<u>2.0 Project information</u>

2.1 What is the contract amount for the project?

2.2 What type of procurement structure was used on the project?

2.3 If PPP, how many concessionaires are involved in the project?

2.4 How long has the project been in operation?

2.5 Who is responsible for operations and management of the project?

<u>3.0 Feasibility studies</u>

3.1 When was the feasibility study for the project undertaken?

3.2 Who was involved in the feasibility study?

3.3 What process was used to conduct the feasibility study?

3.4 What methods were used in the feasibility study?

3.5 What type of data (in terms of nature, source, or projected time) were used in the feasibility studies?

3.6 What factors were incorporated in the feasibility study?

<u>4.0 Performance</u>

4.1 How is the project performing?

APPENDIX IV - ETHICAL CLEARANCE CERTIFICATE

RETHINK. REINVENT.

UNIVERSITY OF JOHANNESBURG

Ethics Approval Clearance Certificate

The ethics approval application submitted by

Name of Researcher	[Chioma Sylvia Okoro]
Name of Organization	University of Johannesburg
Name of Faculty	Faculty of Engineering and the Built Environment
Name of Principal Investigator	[Prof Innocent Musonda]

Name of the Research Project [Delivering Sustainable Transportation Infrastructure: Critical Role of an Adequate and Accurate Feasibility Study]

Has been

☒ APPROVED without the need for any modification by the Ethic Committee.

☐ APPROVED in principle but requires modification / additional information as indicated below in the Comments section by the Ethic Committee.

☐ NOT APPROVED and requires modification / additional information as indicated below in the Comments section by the Ethic Committee. Resubmission of the revised Application is required before approval can be granted.

☐ DISAPPROVED without the possibility for resubmission – the information indicated below in the Comments section by the Ethic Committee highlights the reasons for this decision.

16 March 2018

Signature (Chair of Ethics Committee) Date of Ethics Committee Meeting

Ethics Clearance FEBE Page | 1

APPENDIX V - QUESTIONNAIRE

QUESTIONNAIRE COVER LETTER

08 August, 2018

Department of Engineering Management
University of Johannesburg
South Africa

Dear Sir/Madam,

INVITATION TO PARTICIPATE IN A DOCTORAL RESEARCH

I am a Doctoral Candidate undertaking research on transportation infrastructure planning and sustainability. The project, which is sponsored by the University of Johannesburg, has been approved by the university's Ethics Committee. I would be grateful if you could participate in the study.

Attached is a questionnaire measuring attributes of feasibility study and project performance. The results from this study are expected to contribute towards the sustainability of transport projects.

You are therefore kindly requested to complete the questionnaire. No names are required on the questionnaire. Participation is voluntary. The responses will be kept confidential. The questionnaire will take about 15 minutes to complete. The findings from the project will be made available at the Department of Engineering Management of the University of Johannesburg.

For any queries or comments regarding the survey, please contact the undersigned or the study promoter, Prof Innocent Musonda on +27115596655; imusonda@uj.ac.za and co-promoter Dr Justus Ngala Agumba on +27313732466; justusa@dut.ac.za.

Thank you in advance for your co-operation.

Kind regards

Chioma S. Okoro
Ph.D. Candidate
Tel: +27738626360
chiomasokoro@gmail.com

QUESTIONNAIRE ON FEASIBILITY STUDY AND TRANSPORTATION INFRASTRUCTURE SUSTAINABILITY

SECTION A – PROFILE OF RESPONDENT AND PROJECT

Please answer the following questions by marking (X) in the response option which best applies to you.

Profile of respondents

1. Organisation type you work for:

Public	Private

1.2.Please specify organisation

Dept. of Public Works	Munici-pality	Dept. of Transport	Dept. of Roads & Transport	Consulting company	Commer-cial bank	Private lending company	Other (please specify)

2.Position in the organisation

3. Location of the project involved with (Province)

4. Role on the project

Client/ owner	Feasibility study consultant	Planner	Developer	Community liaison officer	Project manager	Investor	Community leader	Other (please specify)

5.Project stage when involved

Project initiation & briefing	Concept & feasibility	Design development	Tender documentation & procurement	Construction & implementation	Close-out	Operation & maintenance

Project characteristics (PC)

PC1. Type of transport project (please specify)

Road	Rail	Bridge	Airport	Tunnel

PC2. Extent of works on the project

New	Expansion/upgrade

PC3. Project financing type

Public	Private	Public-private partnership (PPP)

PC3.1 If PPP, please specify

Design-build-operate	Build-operate-transfer	Joint venture	Other (please specify)

PC3.2 If PPP, please specify number of private investors

One	Two	Three	More than 3

PC4. Contract amount

Less than R50,000,000	R50,000,000 – R100,000,000	More than R100,000,000

PC5. Time allocated to the feasibility stage (in months)

Less than 9	9 - 16	17 - 24	25 - 32	More than 32

PC6. Project's operational period to date (in years)

Less than 3	3 - 5	6 - 8	More than 8

SECTION B – FEASIBILITY STUDY QUALITY

This section is based on the feasibility study for a recent project you were involved in. Please rate your level of agreement on the following statements.

In the feasibility study:		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
FQ1	Alternative solutions were identified for the project					
FQ2	Appropriate information was made available on the alternative solutions					
FQ3	Sufficient information was made available on the alternative solutions					
FQ4	The alternatives were sufficiently evaluated before a decision was made					
FQ5	Experts in feasibility study conducted the study					
FQ6	Sufficient time was allowed to conduct the feasibility study					
FQ7	The operational (future) life of the project was adequately considered					
FQ8	All stakeholders were involved in the decision-making process					
FQ9	All possible risks to the project were clearly identified					
FQ10	Measures were recommended to manage identified risks					
FQ11	Current performance levels match the projected estimates made at the feasibility stage					

SECTION C – FEASIBILITY STUDY ELEMENTS

Please rate your level of agreement on the following statements.

During the feasibility study, the following data was used:		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
DA1	Traffic data					
DA2	Existing design & structural reports, for upgrade projects					
DA3	Audit observations and performance reports, for upgrade projects					
DA4	International projects as examples					
DA5	Public records and manufacturers					
DA6	Existing financial and tender records					
DA7	Infrastructure development master plans					
DA8	Household income survey data					
The feasibility study:						
EX1	Was conducted by professionals with relevant experience on feasibility studies					
EX2	Involved independent specialists who had no interest in the project outcome to audit and review it					
EX3	Involved environmental specialists					
EX4	Involved professionals who eventually managed (are managing) the projects during the operational stage					

In the feasibility study, the following criteria were considered:		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
CF1	User comfort during travel					
CF2	Convenience to users					
CF3	Preservation of cultural heritage					
CF4	Speed and travel time					
CF5	Travel costs for commuters					
CF6	User safety					
CF7	Proximity to user daily needs					
CF8	Accessibility to all, including the disabled					
CF9	Local conditions					
CF10	Structural capacity of existing infrastructure, for upgrade projects					
CF11	Condition of existing infrastructure was a major consideration, for upgrade projects					
CF12	Existing businesses/vendors					
CF13	Land use integration					
CF14	Sources of project finance					
CF15	Financial input from private investors					
CF16	Financial self-sustenance of the system					
CF17	Central Government's support of the project from start to finish					
CF18	Management capacity					
CF19	Life cycle cost of the system					
CF20	Stakeholders' interests and needs					
CF21	Competing transportation modes within the locality					
The project was considered feasible based on						
ME1	Traffic growth analysis					
ME2	Best scenario outcome					
ME3	Multi-criteria analysis					
ME4	Costs and benefits analysis					
ME5	Site/location characteristics					
ME6	Design and scope requirements					
ME7	Financing alternatives relative to costs (financial)					
ME8	Rate of return on investment					
ME9	An environmental impact assessment					

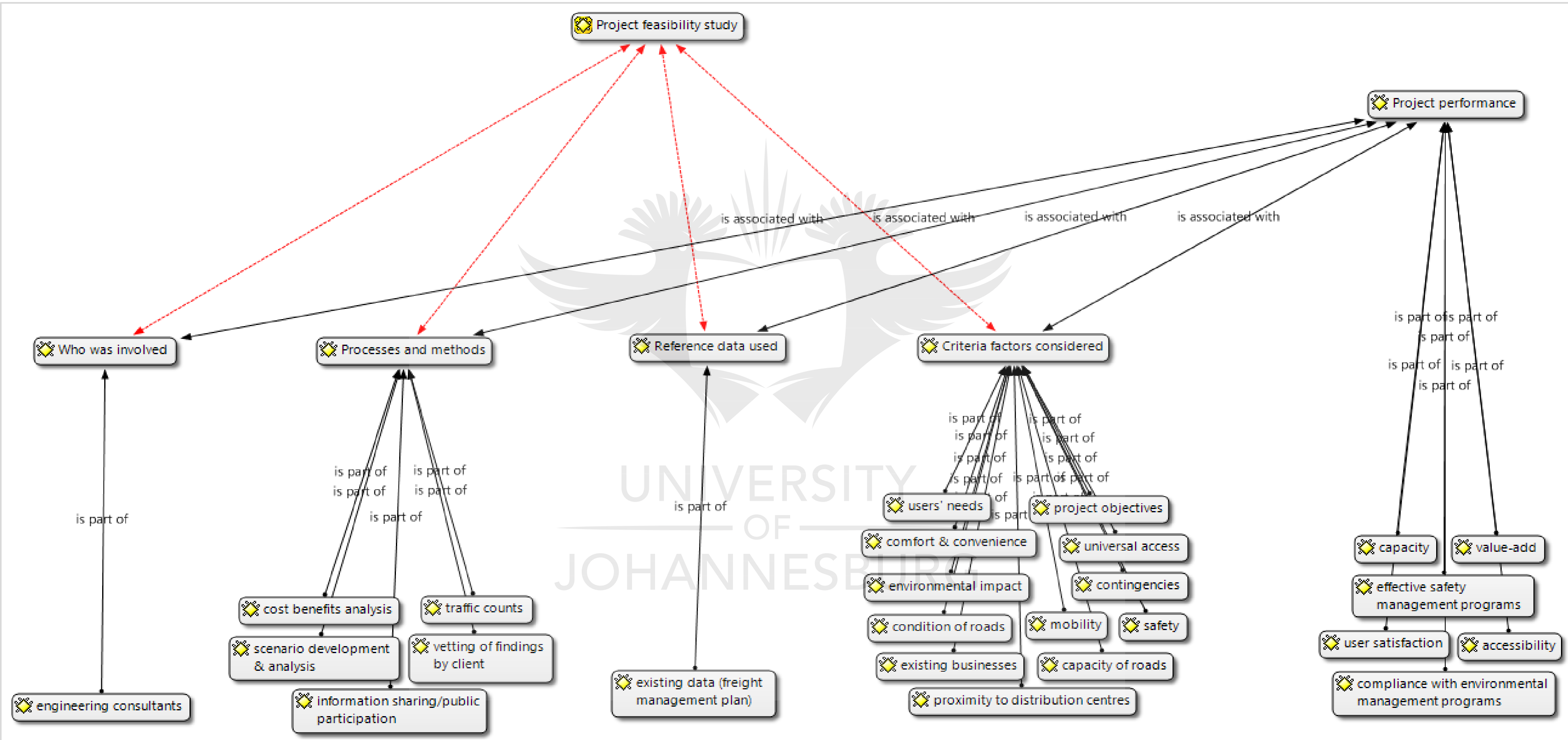
SECTION D – TRANSPORT INFRASTRUCTURE PROJECT SUSTAINABILITY

Please rate your level of agreement on the following statements on project performance.

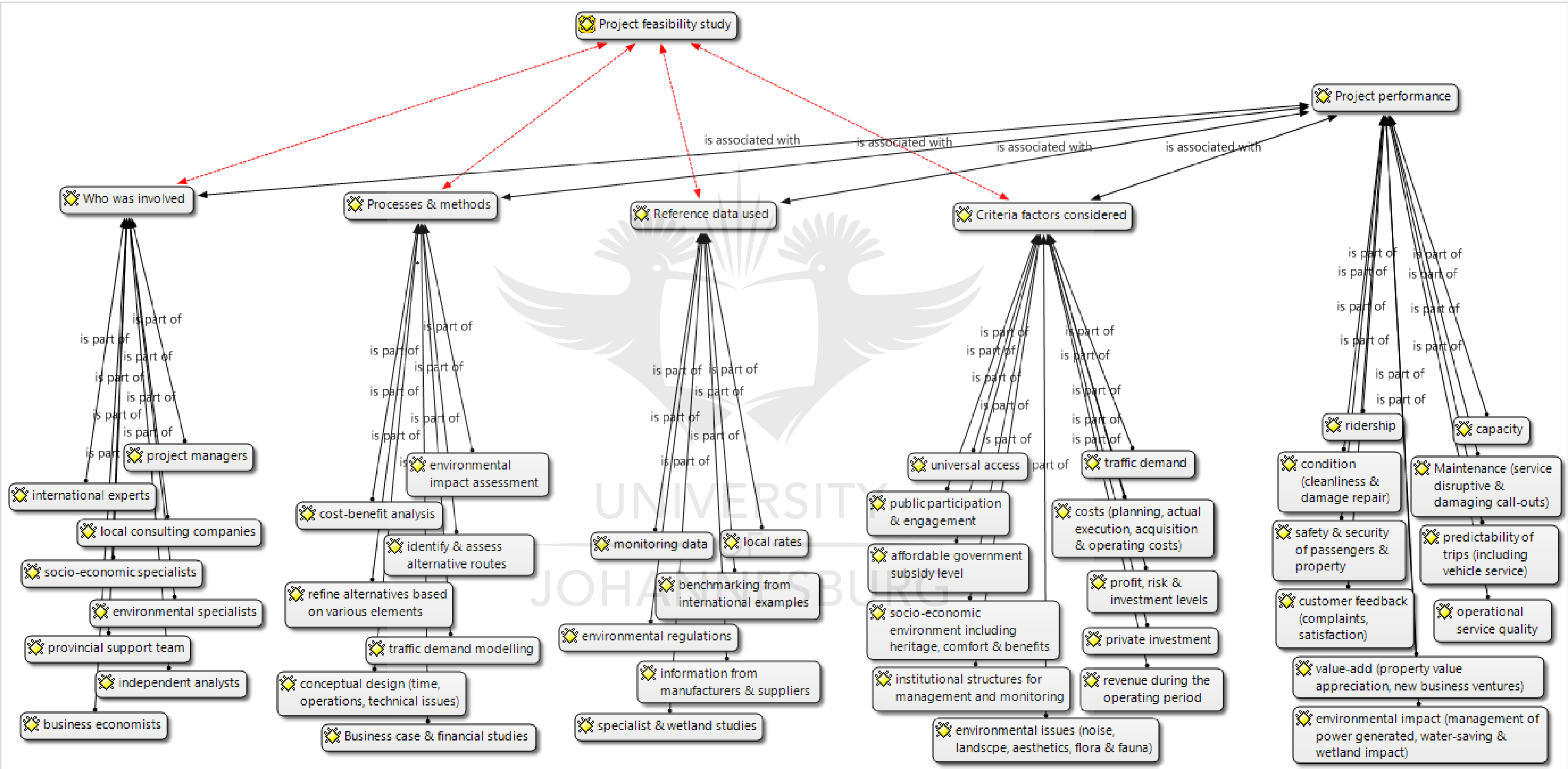
On the project:		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
SE1	There are no complaints about travel times					
SE2	There are no complaints about user discomfort during travel					
SE3	There are no complaints about inconvenience during travel					
SE4	There is no competition between different modes of transport					
SE5	Property values have increased after the infrastructure was built					
SE6	New business ventures have developed after the infrastructure was built					
SE7	Infrastructure is accessible by all including the disabled and elderly					
SE8	Demand for the infrastructure services is as expected					
FI1	Capital invested has been recovered					
FI2	There are no complaints about maintenance resources					
FI3	There are no complaints from investors about revenue					
CI1	The infrastructure is in good condition					
CI2	There are no complaints about the cleanliness of the infrastructure					
CI3	There is no traffic overload					
CI4	The infrastructure, in its present condition, is able to withstand common adverse weather					
SS1	Signage for safety is adequate					
SS2	Fencing (median) is in place for safety					
SS3	Security officers are visible					
SS4	Security cameras are in place					
SS5	Formalised sidewalks are in place for pedestrians					
ST1	The needs of the stakeholders are satisfied					
ST2	Users are satisfied with pricing/charges					
ST3	There are no operational problems					
ST4	The actors are able to work in collaboration with other stakeholders					
ST5	There is clarity of responsibilities among partners					
SQ1	Management responds quickly to user complaints about infrastructure services					
SQ2	Management responds quickly to user complaints about safety incidents					
SQ3	The infrastructure services (rides) are predictable					

APPENDIX VI - ATLAS-TI FINDINGS

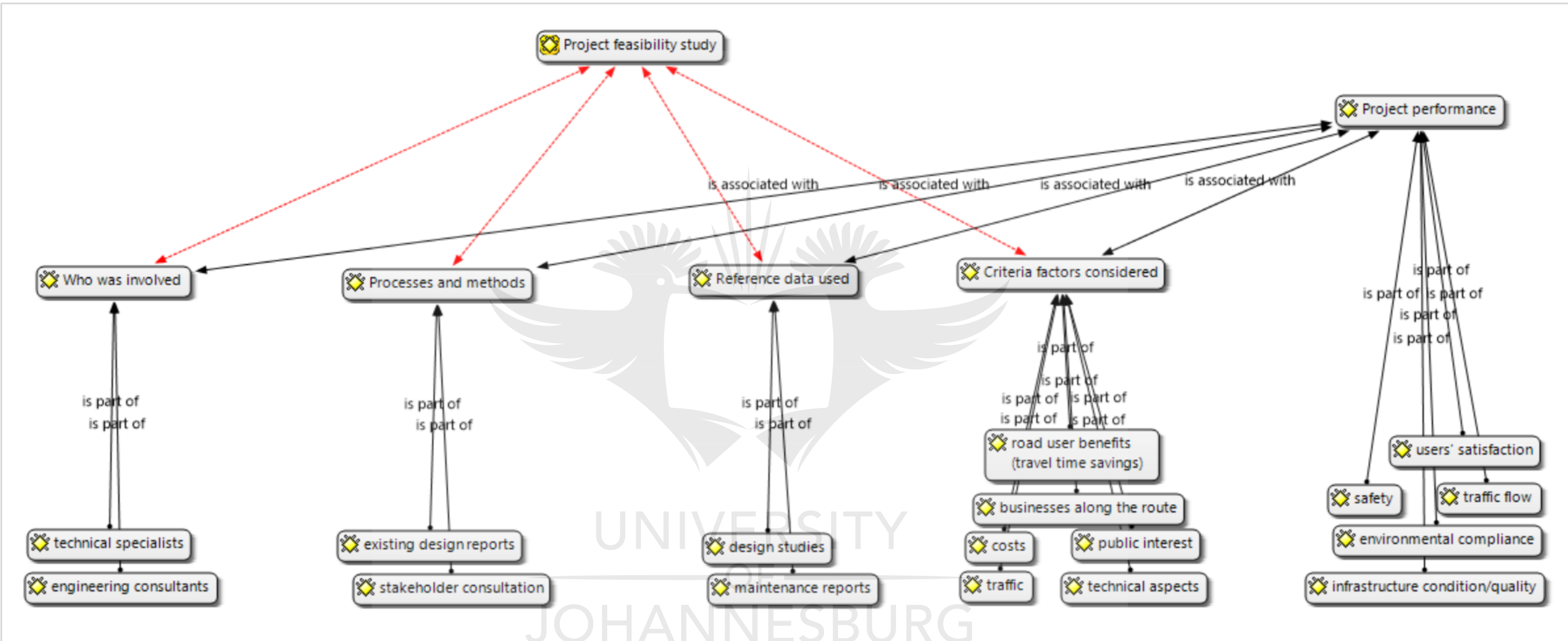
A. CASE STUDY 1 - CITY DEEP HUB



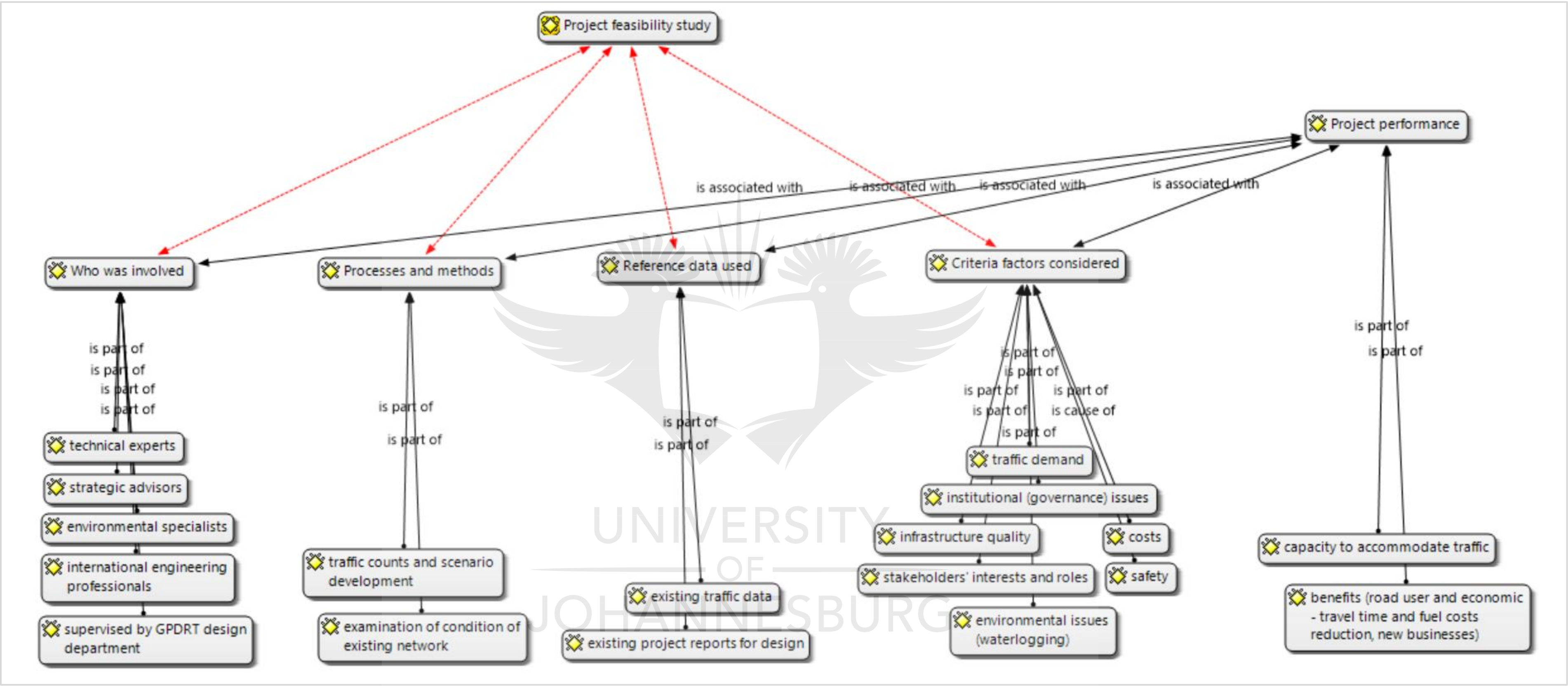
B. CASE STUDY 2 – GAUTRAIN



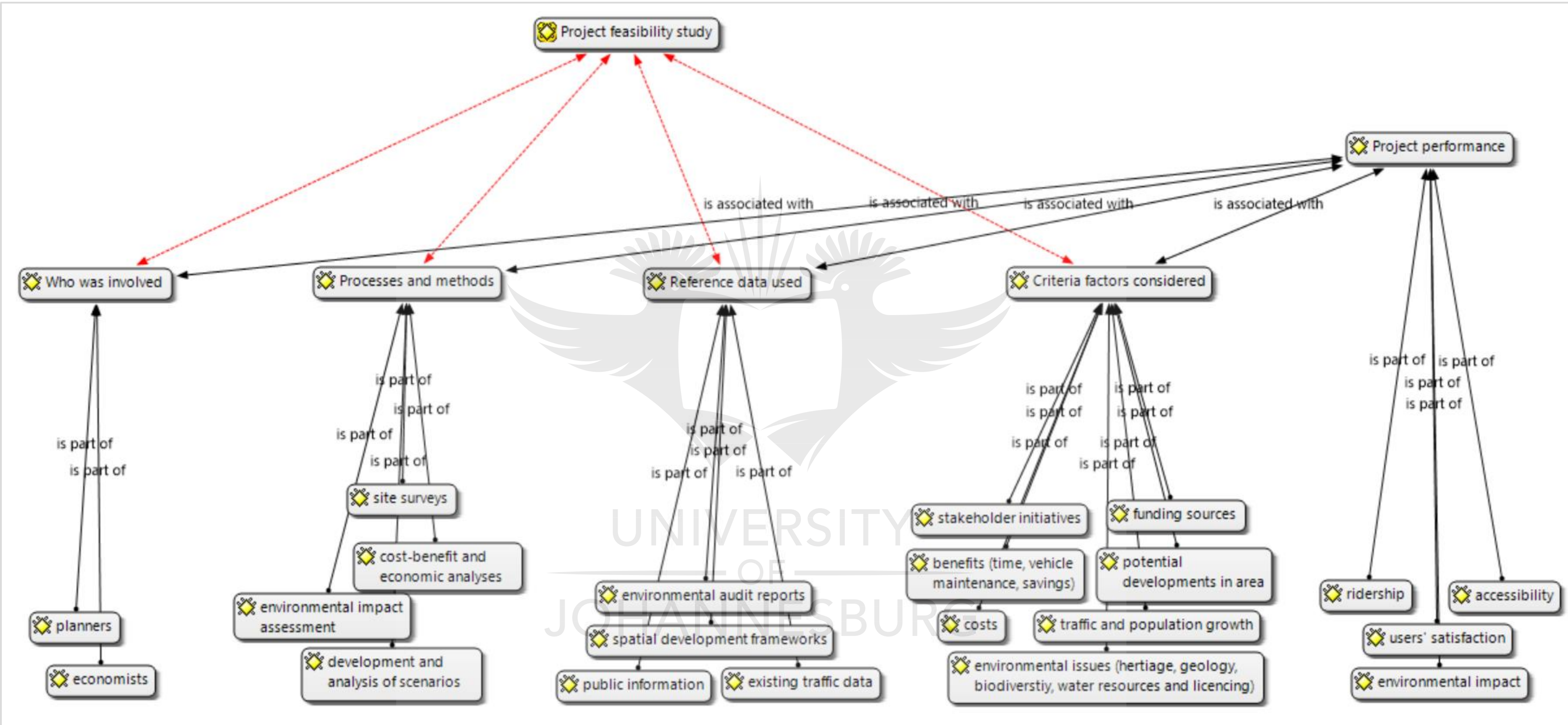
C. CASE STUDY 3 – N12 ROAD



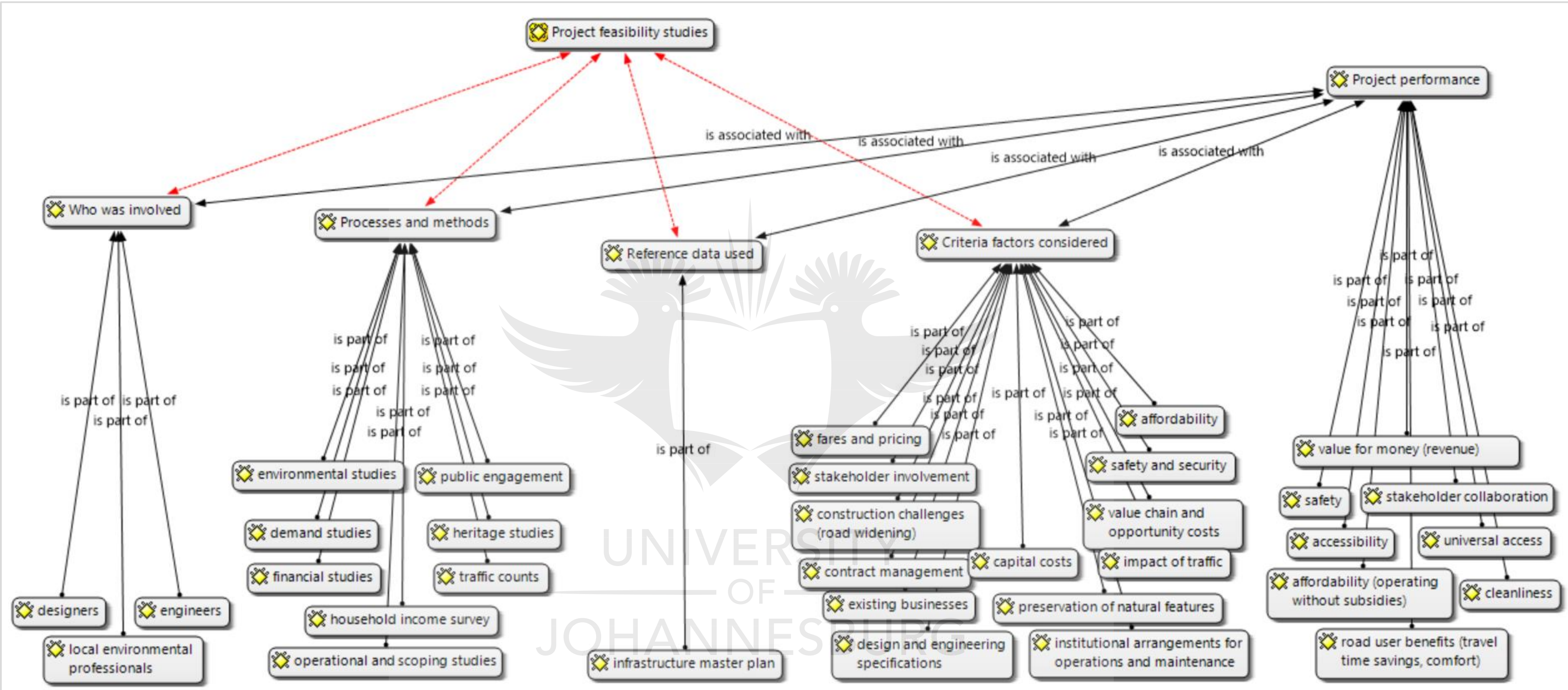
D. CASE STUDY 4 – D1027 CEDAR ROAD



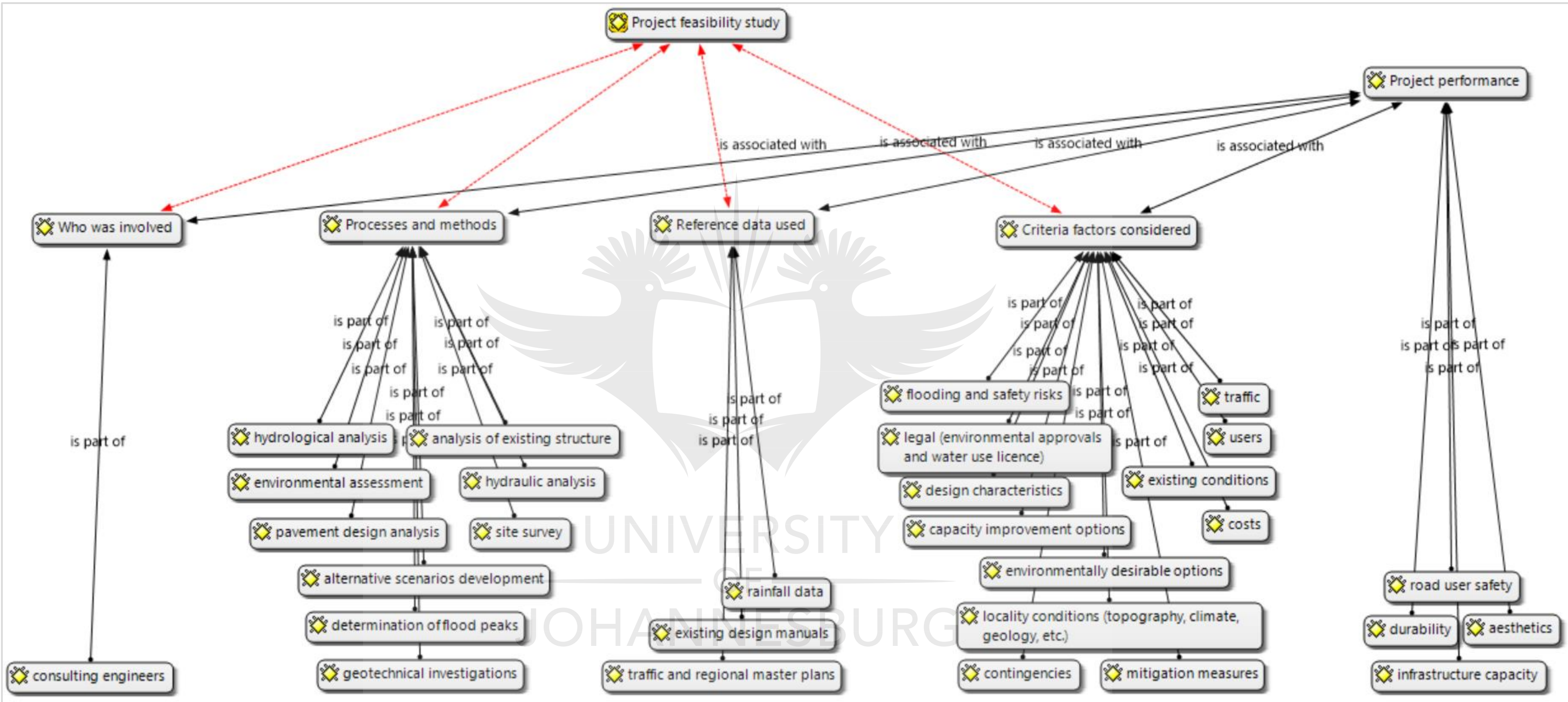
E. CASE STUDY 5 – K46 ROAD



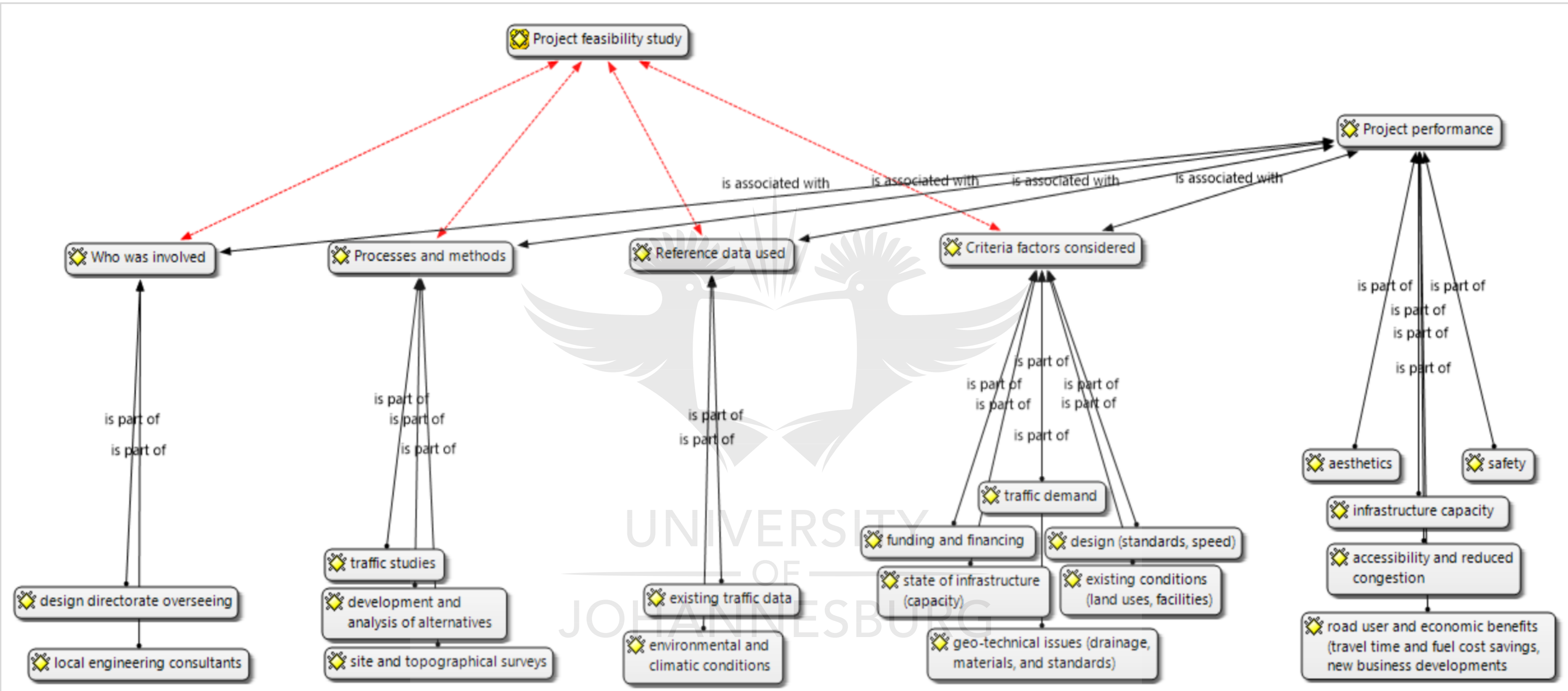
F. CASE STUDY 6 – BRTS



G. CASE STUDY 7 – D603 BRIDGE



H. CASE STUDY 8 – K57 ROAD



APPENDIX VII - FREQUENCY DISTRIBUTION OF RESPONSES ON FEASIBILITY STUDY ELEMENTS

A. FINDINGS ON DATA USED

Measures	Responses (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Traffic data	1.5	3.8	7.6	54.2	32.8
Infrastructure development master plans	0.8	3.8	13.8	53.8	27.7
Existing design and structural reports, for upgrade projects	0	5.3	18.3	49.6	26.7
Audit observations and performance reports, for upgrade projects	0	6.9	24.6	47.7	20.8
Existing financial and tender records	1.5	9.2	20.8	56.2	12.3
Public records and manufacturers	1.5	9.1	26.5	47.0	15.9
International projects as examples	6.8	19.7	25.8	28.0	19.7
Household income survey data	16.8	23.7	28.2	23.7	7.6

B. FINDINGS ON CRITERIA FACTORS CONSIDERED

Measures	Responses (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
User safety	2.3	2.3	12.9	34.1	48.5
Local conditions	1.5	1.5	12.2	50.4	34.4
Condition of existing infrastructure, for upgrade projects	2.3	1.5	16.8	43.5	35.9
Speed and travel time	0.8	7.6	10.6	45.5	35.6
Stakeholders' interests and needs	0	3.8	14.4	52.3	29.5
Land use integration	2.3	4.5	15.2	43.9	34.1
Structural capacity of existing infrastructure, for upgrade projects	1.5	2.3	21.4	42.7	32.1
Convenience to users	2.3	2.3	17.4	48.5	29.5
Management capacity	1.5	5.3	12.1	53.8	27.3
Central Government's support of the project from start to finish	2.3	5.4	14.0	48.1	30.2
Life cycle cost of the system	0.8	9.8	15.2	40.2	34.1
Accessibility to all, including the disabled	0.8	4.5	21.2	45.5	28.0
User comfort during travel	3.0	4.5	19.7	42.4	30.3
Sources of project finance	3.0	6.8	17.4	44.7	28.0
Preservation of cultural heritage	0.8	7.6	22.7	43.9	25.0
Proximity to user daily needs	3.8	7.6	14.5	51.1	22.9
Travel costs for commuters	5.3	9.8	17.4	37.9	29.5
Existing businesses/vendors	3.8	11.4	15.2	43.2	26.5
Competing transportation modes within the locality	6.2	11.6	24.0	38.0	20.2
Financial self-sustenance of the system	7.7	13.1	23.1	36.2	20.0
Financial input from private investors	15.3	16.0	24.4	27.5	16.8

C. FINDINGS ON METHODS USED

Measures	Responses (%)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Design and scope requirements		1.5	10.7	52.7	35.1
An environmental impact assessment		3.8	17.4	38.6	40.2
Costs and benefits analysis		3.8	14.4	47.0	34.8
Site/location characteristics		3.8	13.6	50.8	31.8
Best scenario outcome		5.3	15.3	51.9	27.5
Traffic growth analysis	0.8	6.8	13.6	48.5	30.3
Multi-criteria analysis	1.5	3.8	29.5	39.4	25.8
Financing alternatives relative to costs (financial)	5.3	7.6	28.8	37.1	21.2
Rate of return on investment	7.6	13.6	29.5	28.0	21.2

APPENDIX VIII - EXPLORATORY FACTOR ANALYSIS RESULTS ON TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDY MEASURES

A. KMO AND BARTLETT'S TESTS

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**.824**
Bartlett's Test of Sphericity	Approx. Chi-Square	3520.135
	df	703
	Sig.	.000

B. COMMUNALITIES – FIRST RUN

Items	Initial	Extraction
DA1	.618	.432
DA2	.744	.923
DA3	.749	.722
DA4	.641	.609
DA5	.721	.747
DA6	.683	.492
DA7	.586	.374
DA8	.450	.366
CF1	.864	.913
CF2	.856	.867
CF3	.634	.487
CF4	.792	.729
CF5	.654	.596
CF6	.785	.747
CF7	.758	.585
CF8	.727	.602
CF9	.835	.815
CF10	.781	.677
CF11	.861	.861
CF12	.713	.533
CF13	.676	.522
CF14	.597	.467
CF15	.744	.706
CF16	.768	.749
CF17	.627	.420
CF18	.625	.533
CF19	.694	.514
CF20	.740	.741
CF21	.717	.716
ME1	.758	.673
ME2	.850	.851
ME3	.806	.725

Items	Initial	Extraction
ME4	.753	.697
ME5	.825	.779
ME6	.870	.832
ME7	.663	.521
ME8	.698	.637
ME9	.763	.611

C. SCREE PLOT SHOWING RETAINABLE ITEMS – FIRST RUN

D.VARIANCE EXPLAINED / PATTERN MATRIX – FIRST RUN

	Factor								
	1	2	3	4	5	6	7	8	9
ME5	.916								
ME6	.895								
ME2	.846								
ME4	.728								
ME9	.725								
ME1	.654								
ME3	.519								
CF19	.319								
CF1		1.091							
CF2		1.059							
CF6		.671							
CF4		.533							
CF13		.411							
CF17		.367							
CF15			.933						
ME8			.830						
CF16			.742						
ME7			.697						
CF5		.423	.468						
CF14			.460						
DA6			.427				.346		
CF11				.925					
CF10				.810					
CF12				.496					
CF3				.337					
CF21					1.008				
CF20					.660				.391
CF18					.446				
CF7					.409				
CF8					.357				
DA2						.968			
DA3						.726			
DA1						.376			
DA5							.794		
DA7				.334			.334		
DA4								.655	
DA8					.303			.375	
CF9				.458					.514

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 11 iterations.

E. RESULTS AFTER REMOVING DA8

	Factor								
	1	2	3	4	5	6	7	8	9
ME2	.930								
ME5	.921								
ME6	.902								
ME4	.766								
ME1	.745								
ME9	.710								.337
ME3	.627								
CF19	.355								
CF1		1.094							
CF2		1.068							
CF6		.671							
CF4		.545							
CF13		.448							
CF17		.361							
CF8		.320							
CF15			.855						
ME8	.312		.829						
CF16			.753						
ME7			.684						
CF14			.539						
CF5		.444	.497						
DA4	-.350		.453						
DA6			.413	.310			.391		
CF11				.939					
CF10				.868					
CF9				.523					.374
CF12				.476					
DA7				.386	-.305		.385		
CF21					1.154				
CF20					.529				.370
CF18					.419				
CF7				.313	.326				
DA2						.822		-.316	
DA3						.760			
DA1						.334			
DA5							.815		
CF3								.695	

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 13 iterations.

F. RESULTS AFTER DELETING DA7

	Factor							
	1	2	3	4	5	6	7	8
ME5	.898							
ME2	.898							
ME6	.884							.315
ME4	.756							
ME9	.723							.476
ME1	.712							
ME3	.596							
CF1		1.072						
CF2		1.029						
CF6		.615						
CF4		.502						
CF13		.470						
CF5		.469	.455					
CF17		.391						
CF15			.853					
CF16			.773					
ME8	.307		.753					
ME7			.629					
CF14			.576					
DA4	-.342		.541					
DA6			.433				.325	
CF11				.935				
CF10				.822				
CF12				.499				
CF3				.315				
CF20					.783			
CF21					.755			
CF18					.515			
CF9				.436	.489			
CF8					.399			
CF19	.316				.371			
CF7					.353			
DA2						.908		
DA3						.692		
DA1					.360	.370		
DA5							.862	

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 8 iterations.

G. RESULTS AFTER REMOVING ME9

	Factor							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
ME5	.943							
ME2	.930							
ME6	.830							
ME1	.745							
ME4	.734							
ME3	.589							
CF15		.835						
CF16		.776						
ME8	.392	.653						
CF14		.603						
ME7		.601						
DA4	-.378	.590						
DA6		.443						
CF1			1.002					
CF2			.957					
CF6			.526					
CF4			.439					.431
CF17			.315					
CF11				.937				
CF10				.825				
CF12				.450				
CF3				.386				
CF20					.727			
CF21					.654			
CF9				.526	.528			
CF18					.497			
CF8					.350			
CF19	.327				.343			
DA3						.794		
DA2						.784		
DA1					.359	.371		
CF7					.318		.991	
CF13			.341				.388	
CF5		.326	.331				.352	
DA5								.605

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

H. RESULTS AFTER DELETING DA5

	Factor						
	1	**2**	**3**	**4**	**5**	**6**	**7**
ME5	.953						
ME6	.851						
ME2	.846						.309
ME4	.726						
ME1	.668						
ME3	.516						.307
CF1		1.095					
CF2		1.007					
CF6		.611					
CF4		.532					.392
CF13		.456					
CF5		.439	.377				
CF17		.363					
CF15			.860				
CF16			.797				
ME8	.357		.692				
ME7			.612				
DA4	-.324		.612				
CF14			.599				
DA6			.482				
CF11				.950			
CF10				.821			
CF12				.487			
CF3				.341			
CF20					.790		
CF21					.751		
CF18					.539		
CF9				.463	.517		
CF8					.380		
CF19					.372		
CF7					.328		
DA2						.827	
DA3						.779	
DA1					.348	.364	

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

I. RESULTS AFTER REMOVING CF7

	Factor						
	1	2	3	4	5	6	7
ME5	.957						
ME2	.842						
ME6	.837						
ME4	.727						
ME1	.662						
ME3	.502						.315
CF1		1.062					
CF2		.964					
CF6		.578					
CF4		.488					.488
CF13		.455					
CF5		.438	.386				
CF17		.344					
CF15			.864				
CF16			.800				
ME8	.364		.681				
DA4	- .319		.605				
ME7			.604				
CF14			.597				
DA6			.487				
CF11				.942			
CF10				.814			
CF12				.482			
CF3				.344			
CF20					.772		
CF21					.659		
CF9				.473	.568		
CF18					.530		
CF19					.373		
CF8					.355		.323
DA2						.827	
DA3						.774	
DA1					.349	.359	

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

J. RESULTS AFTER DELETING CF8

	Factor					
	1	2	3	4	5	6
ME2	.950					
ME5	.869					
ME1	.764					
ME6	.764					
ME4	.725					
ME3	.627					
CF15		.913				
CF16		.826				
ME8	.352	.660				
CF14		.570				
ME7		.568				
DA4	-.430	.554				
DA6		.495				
CF1			1.104			
CF2			.925			
CF6			.603			
CF4			.571			
CF13			.456			
CF5		.396	.449			
CF17			.322			
CF11				.937		
CF10				.797		
CF12				.469		
CF3				.347		
CF20					.781	
CF21					.589	
CF9				.490	.570	
CF18					.548	
CF19					.384	
DA2						.842
DA3						.748
DA1					.352	.367

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

K. RESULTS AFTER REMOVING DA1

	Factor					
	1	2	3	4	5	6
ME2	.948					
ME5	.872					
ME6	.765					
ME1	.765					
ME4	.725					
ME3	.633					
CF15		.914				
CF16		.829				
ME8	.357	.658				
CF14		.573				
ME7		.568				
DA4	-.433	.559				
DA6		.501				
CF1			1.118			
CF2			.947			
CF6			.616			
CF4			.581			
CF13			.446			
CF5		.394	.431			
CF17			.325			
CF11				.979		
CF10				.789		
CF12				.477		
CF3				.357		
CF20					.799	
CF21					.566	
CF18					.538	
CF9				.479	.535	
CF19					.388	
DA2						.806
DA3						.761

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

L. RESULTS AFTER DELETING ME8

	Factor					
	1	2	3	4	5	6
ME2	.983					
ME5	.868					
ME1	.796					
ME6	.767					
ME4	.723					
ME3	.671					
CF1		1.109				
CF2		.965				
CF6		.634				
CF4		.580				
CF13		.441				
CF5		.418	.377			
CF17		.327				
CF15			.914			
CF16			.862			
DA4	-.397		.583			
CF14			.566			
ME7			.539			
DA6			.510			
CF11				1.003		
CF10				.784		
CF12				.471		
CF3				.326		
CF20					.779	
CF9				.500	.514	
CF18					.513	
CF21					.496	
CF19	.309				.379	
DA3						.828
DA2						.758

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 6 iterations.

M. RESULTS AFTER REMOVING CF5

	Factor					
	1	2	3	4	5	6
ME2	.983					
ME5	.866					
ME1	.797					
ME6	.766					
ME4	.725					
ME3	.678					
CF1		1.103				
CF2		.963				
CF6		.631				
CF4		.579				
CF13		.429				
CF17		.325				
CF15			.926			
CF16			.871			
DA4	-.398		.590			
CF14			.550			
ME7			.532			
DA6			.512			
CF11				1.006		
CF10				.791		
CF9				.504	.490	
CF12				.478		
CF3				.341		
CF20					.826	
CF21					.524	
CF18					.500	
CF19	.307				.363	
DA3						.814
DA2						.775

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 6 iterations.

N. RESULTS AFTER DELETING CF17

	Factor					
	1	2	3	4	5	6
ME2	.982					
ME5	.868					
ME1	.794					
ME6	.766					
ME4	.724					
ME3	.677					
CF15		.920				
CF16		.869				
DA4	-.393	.585				
CF14		.549				
ME7		.527				
DA6		.515				
CF1			1.099			
CF2			.939			
CF6			.614			
CF4			.564			
CF13			.426			
CF11				1.020		
CF10				.767		
CF12				.474		
CF3				.339		
CF20					.818	
CF9				.481	.508	
CF21					.508	
CF18					.502	
CF19	.308				.370	
DA3						.819
DA2						.770

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 6 iterations.

O. RESULTS AFTER REMOVING CF3

	Factor					
	1	2	3	4	5	6
ME2	.976					
ME5	.855					
ME1	.793					
ME6	.755					
ME4	.717					
ME3	.692					
CF15		.927				
CF16		.874				
DA4	-.399	.557				
CF14		.536				
ME7		.533				
DA6		.517				
CF1			1.092			
CF2			.935			
CF6			.618			
CF4	.306		.567			
CF13			.433			
CF11				1.019		
CF10				.766		
CF12				.477		
CF20					.873	
CF21					.542	
CF18					.529	
CF9				.472	.490	
CF19					.383	
DA3						.841
DA2						.745

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 8 iterations.

P. RESULTS AFTER DELETING DA4

	Factor					
	1	2	3	4	5	6
ME2	.976					
ME5	.897					
ME6	.778					
ME1	.772					
ME4	.728					
ME3	.674					
CF1		1.108				
CF2		.955				
CF6		.622				
CF4		.579				
CF13		.445				
CF15			.991			
CF16			.863			
ME7			.537			
DA6			.537			
CF14			.529			
CF11				1.011		
CF10				.763		
CF12				.473		
CF20					.891	
CF21					.569	
CF18					.520	
CF9				.478	.479	
CF19					.367	
DA3						.808
DA2						.803

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 7 iterations.

Q. RESULTS AFTER REMOVING CF9

	Factor					
	1	2	3	4	5	6
ME2	.980					
ME5	.908					
ME6	.799					
ME1	.773					
ME4	.749					
ME3	.712					
CF1		1.097				
CF2		.946				
CF6		.625				
CF4		.572				
CF13		.436				
CF15			.997			
CF16			.858			
ME7			.546			
DA6			.541			
CF14			.522			
CF11				.978		
CF10				.745		
CF12				.466		
CF20					.897	
CF21					.607	
CF18					.509	
CF19					.369	
DA3						.834
DA2						.803

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 7 iterations.

R. RESULTS AFTER DELETING CF19

	Factor					
	1	2	3	4	5	6
ME2	.984					
ME5	.888					
ME6	.783					
ME1	.774					
ME4	.733					
ME3	.705					
CF1		1.080				
CF2		.933				
CF6		.605				
CF4		.579				
CF13		.415				
CF15			.987			
CF16			.844			
ME7			.541			
DA6			.534			
CF14			.519			
CF11				.922		
CF10				.833		
CF12				.501		
DA3					.905	
DA2					.715	
CF20						.784
CF21						.576
CF18						.495

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 7 iterations.

APPENDIX IX - EXPLORATORY FACTOR ANALYSIS RESULTS ON FEASIBILITY STUDY QUALITY MEASURES

A. KMO AND BARTLETT'S TESTS

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.819
Bartlett's Test of Sphericity	Approx. Chi-Square	668.293
	df	45
	Sig.	.000

B. ANTI-IMAGE CORRELATIONS

	FQ1	FQ4	FQ5	FQ6	FQ8	FQ9	FQ10	EX2	EX3	EX4
FQ1	**.906a**	-.320	-.010	-.072	-.038	-.045	-.042	-.135	.051	.032
FQ4	-.320	**.865a**	-.106	-.079	-.124	.048	-.158	.209	-.175	-.305
FQ5	-.010	-.106	**.802a**	-.533	-.020	-.108	-.056	-.393	.047	.146
FQ6	-.072	-.079	-.533	**.792a**	-.133	.063	-.198	.309	-.170	.078
FQ8	-.038	-.124	-.020	-.133	**.891a**	-.423	-.011	-.059	.079	-.004
FQ9	-.045	.048	-.108	.063	-.423	**.805a**	-.551	.169	.063	-.082
FQ10	-.042	-.158	-.056	-.198	-.011	-.551	**.854a**	-.298	-.111	-.002
EX2	-.135	.209	-.393	.309	-.059	.169	-.298	**.654a**	-.065	-.277
EX3	.051	-.175	.047	-.170	.079	.063	-.111	-.065	**.817a**	-.486
EX4	.032	-.305	.146	.078	-.004	-.082	-.002	-.277	-.486	**.764a**

a. Measures of Sampling Adequacy (MSA)

C. INITIAL COMMUNALITIES BEFORE FQ1 WAS REMOVED

	Initial	Extraction
FQ1	.335	.296
FQ4	.573	.538
FQ5	.614	.528
FQ6	.597	.493
FQ8	.518	.522
FQ9	.684	.675
FQ10	.732	.778
EX2	.432	.251
EX3	.518	.556
EX4	.557	.825

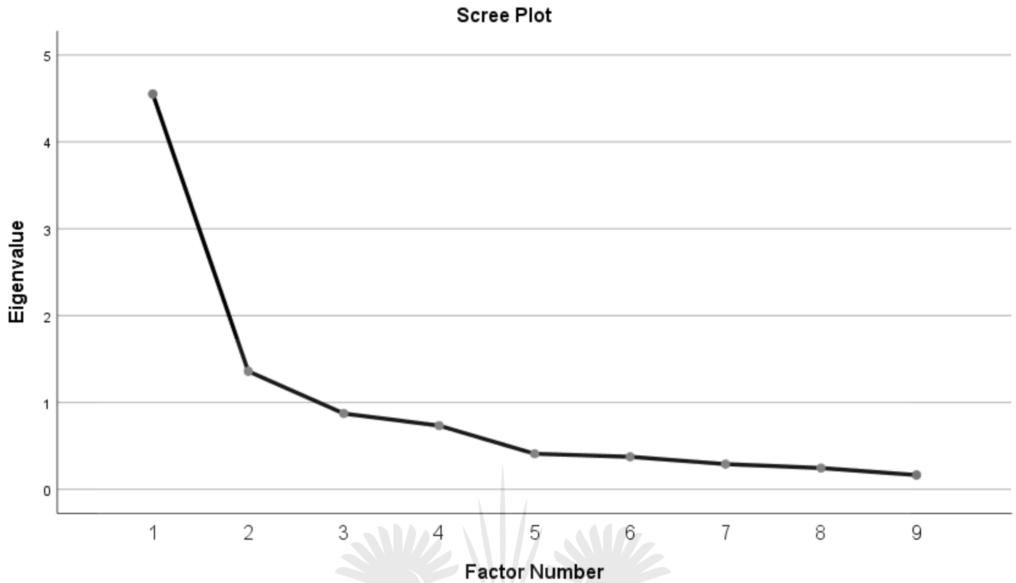
Extraction Method: Maximum Likelihood.

D. INTIAL COMMUNALITIES AFTER FQ1 WAS REMOVED

	Initial	Extraction
FQ4	.525	.520
FQ5	.614	.521
FQ6	.595	.485
FQ8	.517	.522
FQ9	.683	.685
FQ10	.731	.787
EX2	.421	.251
EX3	.517	.549
EX4	.557	.843

Extraction Method: Maximum Likelihood.

E. SCREE PLOT SHOWING TWO FACTORS WITH EIGEN VALUES GREATER THAN 1



F. RESULTS AFTER REMOVING FQ4

	Factor	
	1	2
FQ9	.826	
FQ10	.796	
FQ5	.756	
FQ8	.735	
FQ6	.724	
EX4		.999
EX3		.729
FQ4	.377	.445
EX2		.355

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation..
a. Rotation converged in 3 iterations.

G. RESULTS AFTER REMOVING EX2

	Factor	
	1	2
FQ9	.827	
FQ10	.807	
FQ5	.740	
FQ8	.724	
FQ6	.705	
EX4		.985
EX3		.691
EX2		.358

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 3 iterations.

APPENDIX X - EXPLORATORY FACTOR ANALYSIS RESULTS ON PROJECT SUSTAINABILITY MEASURES

A. KMO AND BARTLETT'S SPERICITY TESTS

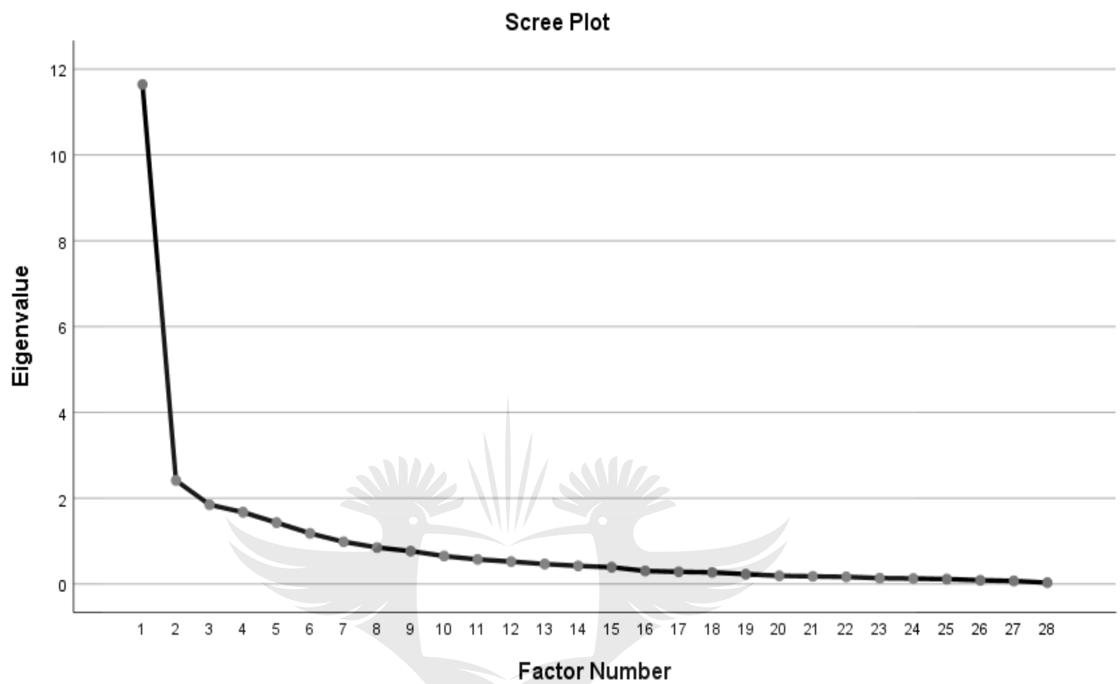
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.855
Bartlett's Test of Sphericity	Approx. Chi-Square	2763.720
	df	351
	Sig.	.000

B. COMMUNALITIES

	Initial	Extraction
SE1	.911	.837
SE2	.880	.856
SE3	.950	.999
SE4	.593	.448
SE5	.734	.623
SE6	.768	.999
SE7	.710	.582
SE8	.655	.560
FI1	.680	.706
FI2	.727	.713
FI3	.775	.855
CI1	.741	.644
CI2	.715	.632
CI3	.672	.575
CI4	.724	.694
SS1	.755	.715
SS2	.741	.577
SS3	.677	.598
SS4	.657	.557
SS5	.688	.430
ST1	.771	.720
ST2	.583	.466
ST3	.777	.682
ST4	.545	.450
SQ1	.789	.746
SQ2	.798	.875
SQ3	.603	.358

Extraction Method: Maximum Likelihood.

C. SCREE PLOT SHOWING SIX FACTORS WITH EIGEN VALUES GREATER THAN 1



D. SECOND RUN – ST5 REMOVED

	Factor					
	1	**2**	**3**	**4**	**5**	**6**
FI1	.971					
FI3	.749			.301	-.364	
FI2	.631					
ST2	.616					
ST3	.541	.307				
ST4	.532					
CI3	.512		.364			
SE3		.995				
SE1		.946				
SE2		.890				
SE4		.529				
CI4			.848			
CI1			.757			
SS1			.728		-.330	
ST1			.578			
SE7			.547			
CI2			.435			
SS5			.375			
SS3				.704		
SS4				.682		
SS2				.525		
SQ2					.871	
SQ1	.328				.624	
SE8			.465		.485	
SQ3					.378	
SE6						.947
SE5				.372		.469

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 8 iterations.

E. THIRD RUN – SQ3 REMOVED

	Factor					
	1	**2**	**3**	**4**	**5**	**6**
FI1	.982					
FI3	.737				-.371	
FI2	.633					
ST2	.620					
ST3	.543	.308				
ST4	.543					
CI3	.519		.352			
SE3		.995				
SE1		.945				
SE2		.889				
SE4		.527				
CI4			.850			
CI1			.770			
SS1			.720		-.321	
ST1			.585			
SE7			.552			
CI2			.438			
SS5			.381			
SS3				.711		
SS4				.685		
SS2				.526		
SQ2					.843	
SQ1	.367				.614	
SE8			.448		.486	
SE6						.950
SE5				.374		.481

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

F. FOURTH RUN – SS5 REMOVED

	Factor					
	1	2	3	4	5	6
FI1	.989					
FI3	.731			-.390		
FI2	.641					
ST2	.626					
ST3	.550	.315				
ST4	.546					
CI3	.532		.377			
SE3		.992				
SE1		.948				
SE2		.881				
SE4		.523				
CI4			.888			
CI1			.757			
SS1			.749			
ST1	.304		.511			
SE7			.450	.312		.308
CI2			.438			
SQ2				.857		
SQ1	.369			.621		
SE8			.416	.522		
SS4					.767	
SS3					.755	
SS2			.301		.472	
SE6						.967
SE5					.301	.486

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 8 iterations.

G. FIFTH RUN – SE5 REMOVED

	Factor				
	1	2	3	4	5
SS1	.893				
CI4	.878				
CI1	.792				
SE6	.595				
SE7	.592			.328	
CI2	.477				
ST1	.400				
SE3		1.013			
SE1		.953			
SE2		.907			
SE4		.565			
FI1			.976		
FI3			.738	-.384	
ST2			.608		
FI2	.324		.596		
ST3		.363	.496		
ST4			.460		
CI3	.332		.432		
SQ2				.874	
SQ1			.390	.589	
SE8	.398			.576	
SS4					.791
SS3					.753
SS2	.313				.413

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

H. SIXTH RUN – SE8 REMOVED

	Factor				
	1	**2**	**3**	**4**	**5**
CI4	.914				
SS1	.875				
CI1	.819				
SE7	.662				
SE6	.627				
CI2	.516				
ST1	.434				
SE3		1.018			
SE1		.959			
SE2		.908			
SE4		.571			
FI1			.989		
FI3			.749		-.370
ST2			.621		
FI2	.316		.596		
ST3		.360	.490		
ST4			.473		
CI3	.337		.425		
SS4				.790	
SS3				.756	
SS2	.329			.423	
SQ2					.859
SQ1			.363		.585

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 6 iterations.

I. SEVENTH RUN – SQ1 REMOVED

	Factor				
	1	**2**	**3**	**4**	**5**
SS1	.957				
CI4	.911		-.318		
CI1	.771				
SE6	.673				
SE7	.627				
CI2	.489				
ST1	.382				.327
SE3		1.020			
SE1		.959			
SE2		.904			
SE4		.564	.309		
FI1			1.017		
ST2			.648		
FI3			.628		-.415
ST3		.353	.555		
FI2	.351		.543		
ST4			.539		
CI3	.355		.404		
SS4				.789	
SS3				.778	
SS2	.327			.419	
SQ2					.661

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

J. EIGHTH RUN – CI3 REMOVED

	Factor				
	1	**2**	**3**	**4**	**5**
SS1	.927				
CI4	.888		-.313		
CI1	.788				
SE6	.701				
SE7	.665				
CI2	.505				
ST1	.398				.313
SE3		1.016			
SE1		.960			
SE2		.892			
SE4		.569	.315		
FI1			.993		
ST2			.652		
FI3			.612		-.447
ST4			.552		
ST3		.376	.551		
FI2	.364		.530		
SS4				.829	
SS3				.802	
SS2				.454	
SQ2					.637

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 7 iterations.

K. NINTH RUN – FI2 REMOVED

	Factor				
	1	**2**	**3**	**4**	**5**
CI4	.885				
SS1	.877				
CI1	.814				
SE7	.704				
SE6	.697				
CI2	.532				
ST1	.436		.369		
SE3		1.008			
SE1		.956			
SE2		.884			
SE4		.560	.352		
FI1			.974		
ST2			.674		
ST4			.595		
ST3		.375	.587		
SS4				.864	
SS3				.836	
SS2				.479	
FI3			.511		-.649
SQ2			.330		.483

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 8 iterations.

L. TENTH RUN – SQ2 REMOVED

	Factor			
	1	2	3	4
CI1	.852			
CI4	.844			
SS1	.787			
SE7	.718			
SE6	.697			
CI2	.566			
ST1	.459			
SE3		1.014		
SE1		.946		
SE2		.909		
SE4		.581	.307	
FI1			.968	
ST2			.646	
ST3		.389	.525	
ST4			.519	
FI3			.510	
SS4				.858
SS3				.801
SS2	.317			.442

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 6 iterations.

M. ELEVENTH RUN – ST3 REMOVED

	Factor			
	1	2	3	4
CI1	.850			
CI4	.844			
SS1	.785			
SE7	.711			
SE6	.690			
CI2	.569			
ST1	.459			
SE3		1.003		
SE1		.934		
SE2		.886		
SE4		.591	.314	
FI1			.886	
ST2			.681	
FI3			.525	
ST4			.494	
SS4				.890
SS3				.799
SS2	.304			.444

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 5 iterations.

N. TWELFTH RUN - SS2 REMOVED

	Factor			
	1	**2**	**3**	**4**
CI1	.851			
CI4	.840			
SS1	.761			
SE7	.711			
SE6	.673			
CI2	.566			
ST1	.463			
SE3		1.006		
SE1		.926		
SE2		.892		
SE4		.604	.308	
FI1			.892	
ST2			.669	
FI3			.531	
ST4			.495	
SS4				.918
SS3				.724

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 5 iterations.

O. THIRTEENTH RUN – SE4 REMOVED

	Factor			
	1	**2**	**3**	**4**
CI1	.860			
CI4	.844			
SS1	.753			
SE7	.716			
SE6	.668			
CI2	.546			
ST1	.462			
SE3		1.007		
SE1		.927		
SE2		.898		
FI1			.914	
ST2			.683	
FI3			.564	
ST4			.475	
SS4				.887
SS3				.751

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.
Rotation converged in 5 iterations.

APPENDIX XI - SKEWNESS AND KURTOSIS TESTS BEFORE DELETING OUTLIERS

Construct	Variable	Skewness	Kurtosis	Multivariate kurtosis (*Mardia's* coefficient)
Transportation infrastructure feasibility study	CF18	-1.066	1.481	**204.848**
	CF21	-.616	-.275	
	CF20	-.637	.246	
	DA2	-.554	-.080	
	DA3	-.380	-.349	
	CF12	-.812	-.017	
	CF10	-.788	.751	
	CF11	-1.102	1.678	
	CF4	-.995	.630	
	CF6	-1.367	1.916	
	CF2	-1.033	1.604	
	CF1	-.930	.764	
	CF14	-.918	.582	
	DA6	-.819	.652	
	ME7	-.619	-.013	
	CF16	-.517	-.528	
	CF15	-.227	-1.026	
	ME3	-.484	.059	
	ME4	-.690	.081	
	ME1	-.872	.551	
	ME6	-.582	.289	
	ME5	-.679	.258	
	ME2	-.654	.193	
Feasibility study quality	EX4	-.996	.850	**34.868**
	EX3	-1.055	1.467	
	FQ6	-.734	.161	
	FQ5	-.825	1.257	
	FQ8	-.708	.268	
	FQ10	-1.193	1.725	
	FQ9	-1.177	.963	
Project sustainability elements	SS3	-.320	-.304	**114.870**
	SS4	-.467	-.506	
	ST4	-.205	.271	
	FI3	-.329	.127	
	ST2	-.163	.389	
	FI1	-.132	.022	
	SE2	-.413	-.393	
	SE1	-.316	-.697	
	SE3	-.507	.055	
	ST1	-.348	-.370	
	CI2	-.486	-.028	
	SE6	-.532	.130	
	SE7	-.453	-.292	
	SS1	-1.085	1.372	
	CI4	-1.095	1.826	
	CI1	-.839	1.332	

APPENDIX XII - MAHALANOBIS D^2 DISTANCE NORMALITY TEST BEFORE DELETING OUTLIERS

Construct	Observation number	Mahalanobis d-squared	*p* value
Transportation infrastructure feasibility study (TIFS)	125	86.436	.000
	86	74.155	.000
	42	66.600	.000
	126	64.656	.000
	57	61.394	.000
	87	56.290	.000
	95	54.034	.000
	53	49.944	.001
	62	49.027	.001
	7	47.642	.002
	105	47.477	.002
Feasibility study quality (FQ)	125	41.864	.000
	53	33.315	.000
	42	30.336	.000
	90	23.519	.001
	84	21.115	.004
Project sustainability (PS)	13	52.556	.000
	95	46.500	.000
	44	43.628	.000
	37	42.682	.000
	110	42.225	.000
	53	41.249	.001
	100	40.155	.001
	86	39.156	.001
	36	39.003	.001
	87	38.235	.001
	9	38.051	.001
	22	38.051	.001
	2	36.724	.002
	57	35.229	.004
	46	35.221	.004

APPENDIX XIII - NORMALITY TESTS WITH 125 CASES (AFTER DELETING OUTLIERS)

A. TRANSPORTATION INFRASTRUCTURE FEASIBILITY STUDIES

Variable	Skewness	Kurtosis	Critical ratio
CF18	-.957	1.207	2.754
CF21	-.624	-.196	-.448
CF20	-.596	.267	.609
DA2	-.506	-.112	-.257
DA3	-.323	-.388	-.884
CF12	-.735	-.070	-.159
CF10	-.614	.334	.763
CF11	-.789	.668	1.525
CF4	-.859	.324	.739
CF6	-1.252	1.560	3.560
CF2	-.894	1.279	2.919
CF1	-.868	.759	1.733
CF14	-.940	.715	1.633
DA6	-.819	.802	1.830
ME7	-.590	.076	.172
CF16	-.504	-.459	-1.049
CF15	-.268	-.908	-2.073
ME3	-.143	-.866	-1.977
ME4	-.643	-.036	-.082
ME1	-.711	.031	.070
ME6	-.577	.250	.571
ME5	-.617	.172	.393
ME2	-.562	.243	.554
Multivariate		**139.097**	**22.929**

B. FEASIBILITY STUDY QUALITY

Variable	Skewness	Kurtosis	Critical ratio
EX4	-.929	.665	1.518
EX3	-.935	1.110	2.533
FQ6	-.648	.058	.132
FQ5	-.769	1.506	3.436
FQ8	-.599	.251	.573
FQ10	-1.189	2.078	4.742
FQ9	-1.224	1.267	2.891
Multivariate		**21.935**	**10.924**

C. PROJECT SUSTAINABILITY MEASURES

Variable	Skewness	Kurtosis	Critical ratio
SS3	-.220	-.433	-.988
SS4	-.467	-.366	-.836
ST4	.051	-.322	-.734
FI3	-.307	.266	.608
ST2	.015	.375	.856
FI1	.047	-.036	-.081
SE2	-.407	-.351	-.802
SE1	-.338	-.620	-1.415
SE3	-.440	.087	.199
ST1	-.313	-.272	-.621
CI2	-.497	.101	.230
SE6	-.555	.190	.433
SE7	-.443	-.239	-.545
SS1	-1.089	1.433	3.270
CI4	-1.101	1.818	4.149
CI1	-.826	1.286	2.935
Multivariate		**110.812**	**25.811**

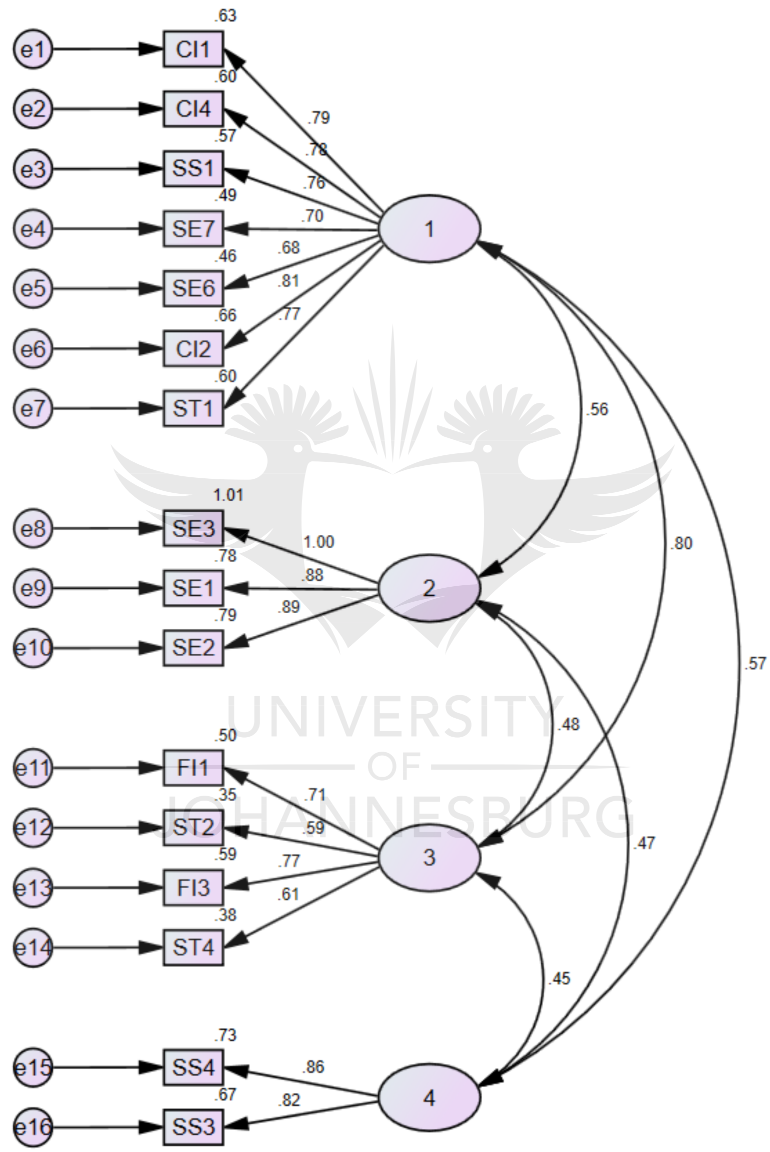
APPENDIX XIV - CONFIRMATORY FACTOR ANALYSIS RESULTS ON TRANSPORTATION INFRASTUCTURE FEASIBILITY STUDY MODEL

A. STANDARDISED RESIDUAL COVARIANCES – FIRST RUN

	CF18	CF21	CF20	DA2	DA3	CF12	CF10	CF11	CF4	CF6	CF2	CF1	CF14	DA6	ME7	CF16	CF15	ME3	ME4	ME1	ME6	ME5	ME2
CF18	.000																						
CF21	-.114	.000																					
CF20	-.212	.293	.000																				
DA2	.514	-1.210	.909	.000																			
DA3	-.089	-1.290	-.035	.000	.000																		
CF12	.686	1.469	.902	-.237	-.433	.000																	
CF10	.954	-.334	-.010	.887	1.436	-.720	.000																
CF11	-.380	-.286	.008	-.322	-.221	.074	.043	.000															
CF4	.541	2.544	1.831	.034	-.452	.881	-.021	-.197	.000														
CF6	1.117	1.596	1.282	.342	-.715	2.603	.846	1.257	1.705	.000													
CF2	.633	-.385	-.203	.418	-.557	1.114	-.493	-.057	-.601	-.147	.000												
CF1	.080	-.372	-1.377	.407	.188	.901	-.476	-.465	-.029	-.498	.217	.000											
CF14	1.851	.504	.411	.975	1.355	1.920	1.706	1.922	1.741	1.129	.856	.588	.000										
DA6	3.585	-.056	.356	2.722	1.640	1.362	1.536	.999	-.204	.456	-.044	-.215	.614	.000									
ME7	1.605	.361	.612	-.187	.474	.500	-.655	-.321	1.460	.248	.379	-.488	-.260	.936	.000								
CF16	.759	.222	-.562	-.703	-.650	1.935	-.484	-.090	2.475	.164	-.107	.205	-.031	-.756	-.164	.000							
CF15	.317	-.817	-1.839	-.184	-.032	.491	-1.100	-1.495	1.148	-.716	-1.474	-1.470	-.142	.508	-.437	.349	.000						
ME3	-.415	-1.098	.276	-.633	-.285	1.404	-.422	-.799	2.709	2.028	-.828	-.553	.890	.765	2.040	.975	.903	.000					
ME4	-.344	-.795	.525	.379	1.117	1.055	.670	.322	2.507	2.552	.366	.332	.582	.894	2.193	.020	-.682	.831	.000				
ME1	-.331	-.501	1.271	.010	.312	.276	-.873	-.661	2.750	1.760	-.383	-.791	1.123	.503	2.340	.510	.003	.234	-.142	.000			
ME6	-.788	-1.426	.713	.117	.963	1.522	-.250	.439	2.232	1.908	-.284	-.687	.794	-.301	2.088	-.229	-1.556	-.427	.040	-.237	.000		
ME5	-.945	-.779	.488	-.756	.089	1.497	-.564	.026	2.229	1.963	-.856	-1.177	.170	-.649	1.511	-.457	-2.232	-.339	-.145	-.566	.461	.000	
ME2	-1.391	-.030	.705	-.876	-.261	.948	-.682	-.123	3.144	2.158	-.897	-.660	-.084	-1.295	1.612	-.373	-1.808	.236	-.351	.768	-.249	.071	.000

APPENDIX XV - CONFIRMATORY FACTOR ANALYSIS RESULTS ON PROJECT SUSTAINABILITY MODEL

A. INPUT PS MODEL WITH STANDARDISED ESTIMATES



B. STANDARDISED RESIDUAL COVARIANCES – PS INPUT RUN

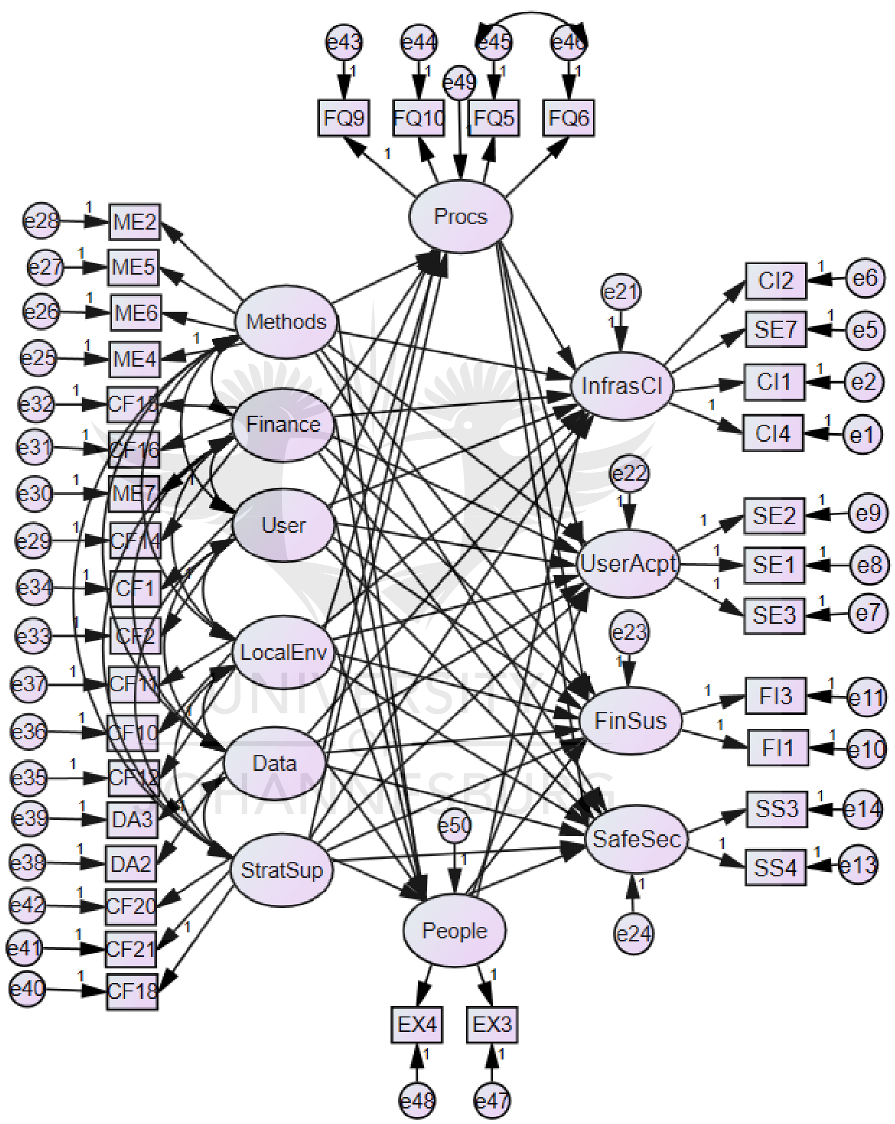
	SS3	SS4	ST2	FI3	FI1	SE2	SE1	SE3	CI2	SE7	SE6	SS1	CI1	CI4
SS3	.000													
SS4	.000	.000												
ST2	.040	-.268	.000											
FI3	.876	-.138	-.547	.000										
FI1	-.243	-1.047	.904	.121	.000									
SE2	.404	1.328	.821	-.930	-1.575	.000								
SE1	-.877	-.458	1.522	.124	-.693	-.024	.000							
SE3	-.561	.469	1.411	-.036	-.942	.001	-.001	.000						
CI2	.968	-.098	1.498	.384	.588	.850	1.374	1.080	.000					
SE7	.625	.074	-.247	-1.268	-.224	-.767	-.151	-.742	.162	.000				
SE6	-.575	-1.001	.510	1.405	.090	-1.202	-.559	-.973	-.319	1.323	.000			
SS1	-1.029	-1.282	-.226	.924	-.649	-.564	-.123	-.385	-.630	-.393	.532	.000		
CI1	.790	.236	-.474	-.315	-.286	.599	-.129	-.246	.283	.440	-.244	-.548	.000	
CI4	.821	.694	-.760	-.597	-1.832	1.172	.417	.697	-.266	-.458	-1.022	1.242	.334	.000

C. SQUARED MULTIPLE CORRELATIONS

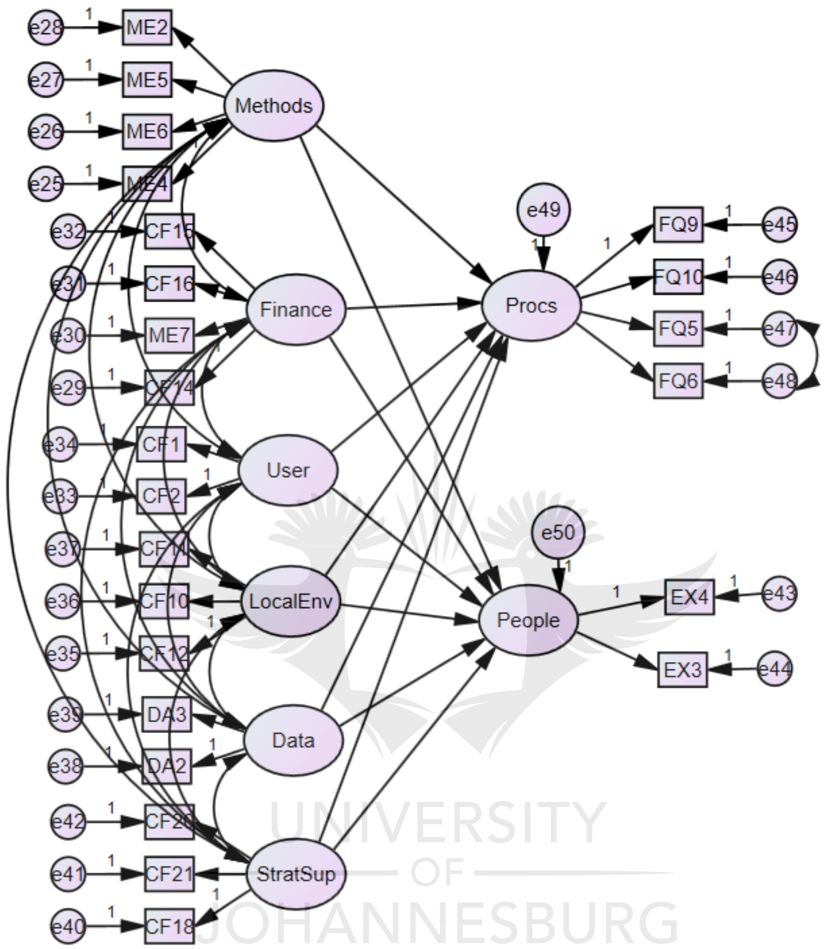
Item	Estimate
SS3	.716
SS4	.690
ST2	.342
FI3	.649
FI1	.485
SE2	.788
SE1	.778
SE3	1.007
CI2	.716
SE7	.441
CI1	.625
CI4	.553

APPENDIX XVI – STRUCTURAL MODELS

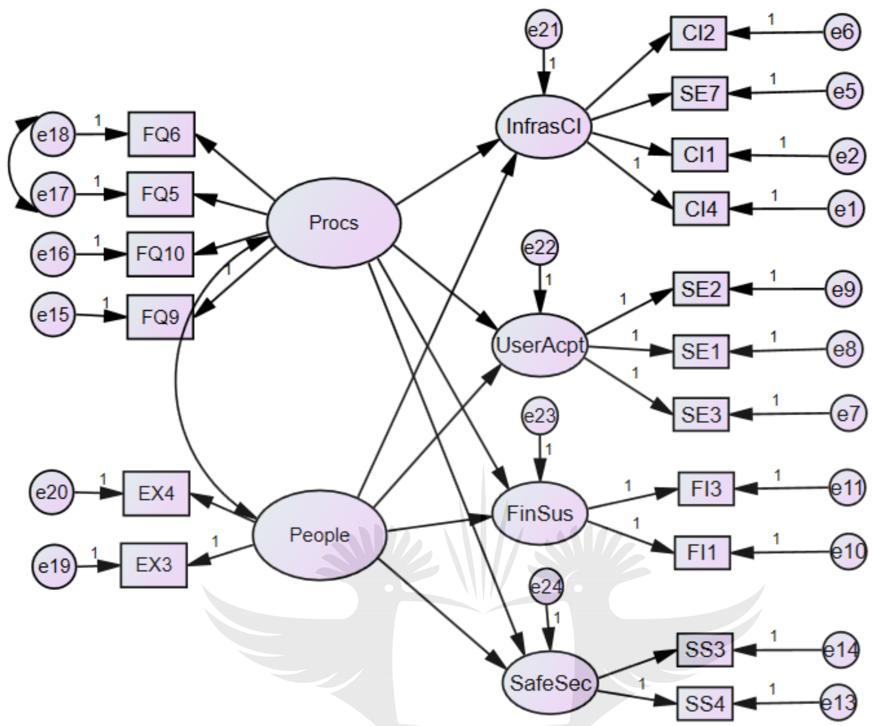
A. FULL LATENT MODEL



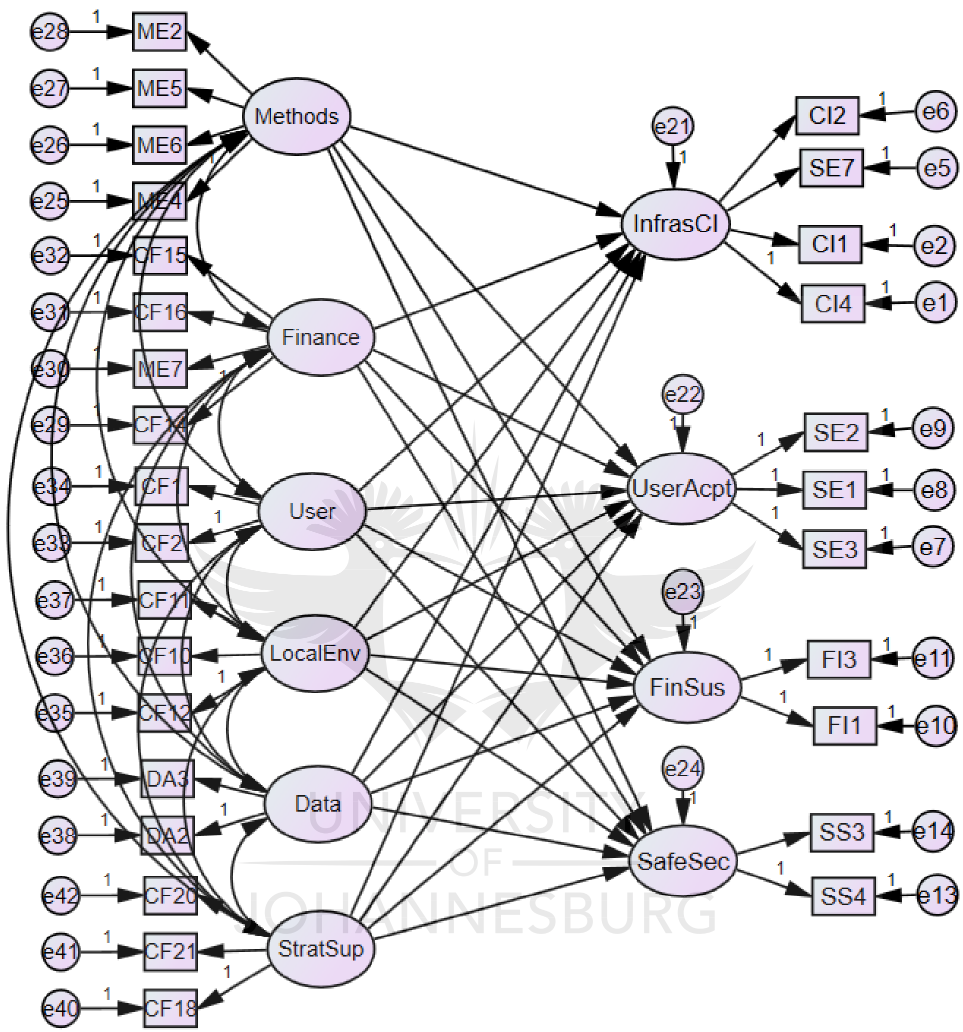
B. MODEL H1 TESTED – DIRECT INFLUENCE OF TIFS ON FQ



C. MODEL H2 TESTED – DIRECT INFLUENCE OF FQ ON PS



D. MODEL H3 TESTED – DIRECT INFLUENCE OF TIFS ON PS



E. STRUCTURAL MODEL - PATH H4 TESTING (INDIRECT INFLUENCE OF TIFS ON PS)